DOCUMENT RESUME

ED 099 208 88 SE 018 219

TITLE	Tire Production and Pollution Control. Environmental Education Curriculum. Revised.
INSTITUTION	Topeka Public Schools, Kans.
SPONS AGENCY	Bureau of Elementary and Secondary Education (DHEW/OE), Washington, D.C.
PUB DATE	Dec 73
NOTE	125p.; Best copy available
EDRS PRICE	MF-$0.75 HC-$5.40 PLUS POSTAGE
DESCRIPTORS	*Curriculum Guides; *Environmental Education; Industrial Technology; *Industry; Learning Activities; *Pollution; Science Education; *Secondary School Science; Technology; Wastes
IDENTIFIERS	Elementary Secondary Education Act Title III; ESEA Title III; Tire Production

ABSTRACT

This unit was developed to introduce secondary students to the many facets of a typical, large manufacturing plant - the Topeka Goodyear Tire and Rubber Company - in an effort to increase awareness of sound environmental practices in industry. Its five major foci include the production of tires and quality control procedures; applications of physical science to the design, testing and production of tires; the economics of production and pollution control; solid waste disposal problems and solutions; and sound pollution and its control. Also included are activities relating to tire design and decomposition products of a landfill. A pretest-posttest instrument to aid in evaluating student performance and the behavioral objectives for each major concern are provided. Also included are annotated film and slide tape lists and scripts and patterns for making relevant transparencies. (MLB)

environmental education curriculum

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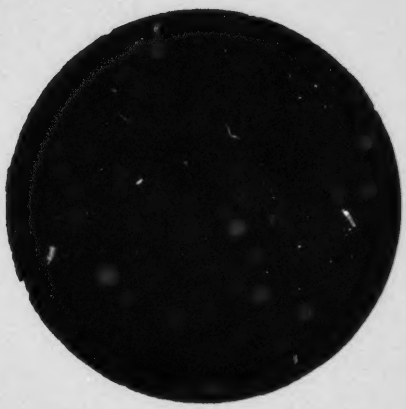

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ENVIRONMENTAL EDUCATION PROJECT
ESEA TITLE III, SECTION 306

Topeka Public and Parochial Schools
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A unit developed by the Environmental Education Project Staff, November, 1972, revised December, 1973, for secondary science students.

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TIRE PRODUCTION AND POLLUTION CONTROL

The work presented or reported herein was performed pursuant to a grant from the United States Office of Education. However, the opinions and material expressed herein do not necessarily reflect the position or policy of the U. S. Office of Education, and no official endorsement by the U. S. Office of Education should be inferred.

Tire Production and Pollution Control

Foreword

The development of our nation's industries has played a crucial role in providing us increasingly high qualities and quantities of food, housing, transportation, and recreation. Industrial development has also increased our air, water, sound, and solid waste pollution problems. Citizen use of the products of the industrial age has led to a growing environmental crisis and an increased demand for diminishing energy reserves. Intelligent cooperation between science, industry, government, and all citizens will be required before man can achieve and maintain a stable balance with his environment.

In an attempt to encourage this cooperation, the Environmental Education Project and its target teachers developed this module to introduce students to the many facets of a typical, large manufacturing plant.

In the production of tires, the Topeka Goodyear Tire and Rubber Company could create air, water, sound, and solid waste pollution. The company has recognized this potential problem and has taken active steps to control, or prevent, the sources of pollution before they harm man or his environment.

This module focuses on five broad topics:

1. Tire production and quality control methods.
2. Applications of physical science properties in the design, testing, and production of tires.
3. Economics of production and pollution control.
4. Solid waste disposal problems and solutions.
5. Sound pollution and its control.

These topics are developed with class and individual activities, films, papers, and a trip to both the Goodyear Tire and Rubber Plant and the aluminum reclamation center in Topeka.

The achievement of the stated goals is guided with behavioral objectives, teacher suggestions, and questions to the students with each activity, film, and paper. The achievement is measured with carefully written and evaluated tests based on the behavioral objectives.

Robert E. King

Robert E. King
Secondary Program Specialist
December 5, 1973

ACKNOWLEDGMENT

The Environmental Education Project for the Topeka Public and Parochial Schools began operation June 29, 1971. The following individuals deserve recognition for the interest, time, and devotion they gave during the difficult stages of planning and writing the project proposal:

Mr. John Ganger, Coordinator of Curriculum for Special Education
Mr. W. I. Green, Director of Special Education
Dr. Quinton Groves, Director of Health, Physical Education, Safety and Athletics
Mr. Clarence "Tuffy" Kellogg, Assistant Director of Health, Physical Education and Safety
Mr. Stanley Martin, Science Supervisor
Mr. Claude Ritchie, Principal, Gage Elementary School
Mr. William Wagaman, Principal, Avondale East Elementary School
Mr. Lawrence R. Gaston, Director of Federal Programs
Dr. Gilbert Wehmeier, Principal, Curtis Junior High School

The needed support given the project by Dr. Merle R. Bolton, superintendent of schools; other members of the central administrative staff; the instruction department; personnel office; business office; data processing department; maintenance department; and Lawrence Gaston, Director of federal programs, is gratefully acknowledged.

Special recognition is given to the Board of Education for the Topeka Public Schools, who approved and are supporting this creative, exemplary, and innovative project.

My sincere gratitude is extended to the program specialists for their tireless efforts in developing this secondary module. Curriculum development and revision has extended the working days for these staff members. My personal thanks are given to Bob King, Glenn Clarkson, and Thad Whiteaker for an outstanding job.

Mr. Dave Overmeyer and Mr. R. A. Wingerson, of the Topeka Goodyear Tire and Rubber Plant, must receive special thanks for assisting in the development of materials and in coordinating our many field trips. Mr. Phil McNeal, of Lapeka, Inc., deserves special thanks for providing material, ideas, and trip assistance in our study of aluminum recycling. Karen Simpson and T. W. Mack are responsible for the sketches.

The enclosed curriculum is the result of input from the project's paraprofessionals and volunteers, science teachers, Community Council members, parents, students, and interested lay citizens.

With the deepest appreciation, I acknowledge the work of the secretarial team. The constant revision, pressures, deadlines, and demands for quality work were handled in a most outstanding manner by Dorothy Booher, Rita Dreiling, Sue Beattie, Joyce Hartman, and Linda Hough.

Donald French
Project Coordinator

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Tire Production and Pollution Control

Module Goals: The module seeks to reinforce and expand knowledge and values in the following areas:

1) Tires - production methods and quality control procedures.
2) Applications of physical science properties to the design, testing, and production of tires.
3) Economics of production and pollution control.
4) Solid waste disposal problems and solutions.
5) Sound pollution and its control.

Optional Concepts: Presented in papers and activities with the unit.

1) Tire design and comparative values.
2) Decomposition products of a landfill.

USE OF TEACHING MATERIALS

The suggested time line (pages 2 - 4) for this module is provided to allow easier planning.

The 'Module Materials List' (page 4) indicates the supplies you need to obtain to teach the module.

Film descriptions (page 5) describe suggested and optional films.

Pages 6 and 7 provide a brief summary of the development and use of the behavioral objectives in this module. The behavioral objectives (pages 8 - 11) indicate the concepts and abilities that most of your class should gain from studying this module.

The posttest (pages 12 - 20) for this module is included with the correct answers circled. This allows you to see the types of questions keyed to the behavioral objectives. Please do not teach the questions, but use the behavioral objectives. Many objectives concern concepts which require interpretation and extrapolation. Teaching the test questions requires only rote memorization. Student pre and posttest results are reported using this form.

Pages 21 - 25 are two optional student papers which could be duplicated and discussed.

The rest of this manual contains the papers available in the student manual. Following each one of the student papers, you will find sheets of green paper. These pages contain: 1) Behavioral objectives tied to the paper; 2) Suggestions for presenting the papers; and 3) Answers to the student self-test questions. Particular attention should be given to the film material before presenting the film.

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Suggested Time Line for Module Activities

This module has several optional papers and activities which may be used, and several audiovisual presentations which may be difficult to schedule. Therefore, the time line is written in the ideal sequence of events with an average time required for teaching each activity indicated in parenthesis. The times, of course, will vary from class to class.

Determine which optional activities you wish to schedule, and schedule the films you wish to use. After you know your film schedules, tailor the time line to your classroom needs. The day, or days planned for each activity may be noted in the blank spaces to the left of each paper to be used.

Day

Before the Field Trip

Arrange the field trip date with the project staff, and obtain the student pretests. Obtain approval for the field trip dates from the building principal (use Paper K-2). Note: Students in wheel chairs may not take this trip.

Locate the classroom materials and begin duplicating all required forms and desired materials listed on page 4, "Module Materials Lists."

_____30 min. 1. Give the pretests. Return all tests and answer sheets as soon as possible to the project for scoring.

_____30 min. 2. Hand out student books, read and discuss the "Introduction," Paper A.

> Duplicate page B-7 if you wish to use it in class. Obtain the two display boards. Obtain the bottles of latex, vinegar, and demonstration equipment for the optional demonstration, page B-9.

_____50 min. 3. Read and discuss Paper B, using the two display boards. Demonstrate the extraction of rubber from latex.

> Obtain the slide-tape presentation, Manufacturing at Goodyear, a slide projector, and cassette tape recorder.

_____30 min. 4. View and discuss the slide-tape presentation, Manufacturing at Goodyear.

> Obtain the rubber rings, rubber bands, beaker and salt needed for the demonstration described on C-4 and 5. Obtain the material for the optional demonstration on C-5, if possible.

_____50 min. 5. Read and discuss Paper C, "Controlling Tire Quality."

> Duplicate pages 21 and 22 of the optional paper, "Differences in Tire Designs" if desired.

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_____30 min. (optional)

6. Read and discuss the paper, "Differences in Tire Designs."

> Obtain class sets of rubber bands, rulers, buckets, and graduate cylinders or 100 gm. masses for the elasticity experiment. An overhead projector should be obtained for use with Transparencies 1, 2, and 3.

> Duplicate D-2 and, if desired D-3 and D-4.

_____10 min. plus 50 min.

7. Organize, carry out, and evaluate the data for the experiment, "Elasticity and Strength of Rubber Bands."

_____40 min. (optional)

8. Do the optional graphing exercise, Pages D-3 and D-4.

Note: D-3 and D-4 in your manual are revised and improved from those in the student manual.

> Obtain class sets of 30 and 4 cm strips of masking tape, string, rulers, plastic tubes, buckets, and graduate cylinders for optional Paper E, "Adhesion of Tape."

> Duplicate page E-3 for the optional experiment, and obtain an overhead projector for use with Transparencies 4 and 5.

_____15 min. plus 50 min.

9. Organize, carry out, and evaluate the data on optional experiment E, "Adhesion of Tape."

> Duplicate page K-3. Send parental permission slips home.

> Duplicate pages 23-25 of the optional experiment, "Trash--Where Does It Go? (Four Experiments)."

_____30 min. (optional)

10. Organize, and initiate experiments suggested in the optional experiment, "Trash--Where Does It Go? (Four Experiments.)"

_____50 min.

11. Read and discuss Paper F, "Economics of Goodyear."

> Obtain a 16 mm film projector.

_____50 min.

12. Read and discuss Paper G, "Noise Pollution." Then view and discuss the film, Hearing - the Forgotten Sense.

> Obtain a cassette tape recorder and slide projector.

_____50 min.

13. Read and discuss Paper H, "Pollution Control at Goodyear." Then view and discuss the tape-slide presentation, Pollution Control at Goodyear.

> Call the Environmental Education Office (232-9374) to confirm the arrangements for the substitute, the times of departure, and number of students participating.
>
> Remind students to return parental permission slips. Notify other teachers of the students who will be taking the field trips.

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_____ 10 min. 14. Give students the appropriate set of field trip rules and regulations, as contained on page K-4. Prepare your lesson plans for the substitute.

Obtain a cassette tape recorder and slide projector.

_____ 50 min. 15. Read and discuss Paper I, "Old Tires - What Can Be Done With Them," and view the tape-slide presentation, Solid Waste Control.

Obtain a 16mm film projector.

_____ 50 min. 16. Read and discuss Paper J, "Trash - Now What " and view the film, Garbage Explosion.

Obtain a cassette tape recorder and slide projector.

_____ 10 min. (Optional) 17. View the tape-slide presentation, Aluminum Recycling, if your class is visiting the Lapeka recycling center.

_____ 3 hrs. 18. Field trip - 3 hours. Give the substitute her instructions. Bring student permission slips. When and if you feel comfortable in the plant, offer to lead a small group of students.

Obtain a cassette tape recorder and slide projector.

_____ 50 min. 19. Review the field trip and module objectives using the behavioral objectives (pages 8-11) and, if possible, the slide tape presentations, Manufacturing at Goodyear, and Pollution Control at Goodyear.

_____ 30 min. 20. Give the post-module test. Fill out the unit evaluation forms, and return the tests and forms to the project office. Test results will be returned in 10 school days.

Module Materials List

The time line above indicates when materials are needed for teaching the papers and exercises in this module. One class of 30 students requires the quantities below.

Curriculum Materials

Basic

1 Teacher's Guide
30 Student Booklets
30 Pre and Post Tests
60 IBM answer sheets
30 Duplicates, pages K-3, B-7, D-2, & E-3
3 Duplicates, page K-2

Optional

30 Duplicates of pages 21-25, D-3, & D-4

Experimental and Demonstration Materials

Basic

1 vial latex, 100 ml vinegar
1 beaker, 1 rubber ring
20 gm Sodium chloride
2 Display Boards
30 rubber bands, 30 rulers
15 buckets
15 100ml graduate cylinders

Optional

15, 30cm strips of tape
30, 4cm strips of tape
30, 1 inch plastic tubes
30. 40cm lengths of string

Audio-Visual Requirements

Basic

Overhead Projector
16mm Film Projector
Cassette Tape Recorder
Slide Projector

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Film Descriptions

The two 16mm films listed below may be obtained from the Topeka Public Schools Audio-Visual Department.

Hearing: The Forgotten Sense - color, 18 minutes Price/Vowell

A good film demonstrating the value of hearing. The film shows how the ear works, general causes of hearing loss, and steps which can be taken to prevent hearing decay.

The Garbage Explosion - black and white, 16 minutes EBE Corp.

A good film showing the causes and potential solutions to our growing problem of solid waste disposal.

Slide-Tape Series

The four slide-tape presentations listed below may be borrowed from the Environmental Education Project Office. All require a cassette tape recorder and carousel slide projector. The scripts are contained in the Appendixes (I - IV) of this manual.

Manufacturing at Goodyear - 15 minutes Local Production

Most of the production machines that will be seen on the Goodyear tour are shown and explained in this series of slides and its accompanying tape. The tape is provided with a five second pause between each slide narration so that the teacher may stop the tape to inject comments and answer student questions.

Pollution Control - 12 minutes Local Production

Goodyear pollution control methods are illustrated and explained in this series of slides and its accompanying tape.

Solid Waste Control - 5 minutes Local Production

Solid waste control methods used in Topeka are illustrated and explained in this series of slides and its accompanying tape.

Recycling Aluminum - 7 minutes Local Production

This series of slides has been modified from a longer production of the Adolph Coors Company. It explains why aluminum recycling is necessary and shows the processes used to reclaim the metal.

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A Word About Behavioral Objectives

The goals of this module are defined through the use of behavioral objectives. The behavioral objectives establish a predetermined goal toward which learning is to be directed and by which attainment may be measured. This unit is intended to develop student changes in both the cognitive (knowledge) and the affective (attitude) domains. The behavioral objectives for this unit contain these basic parts:

1) The concept, or skill being evaluated.
2) The expected criterion (percent of students who should correctly respond).
3) The Bloom's taxonomy level at which the concept will be tested.

All concepts will be evaluated using multiple choice questions with only one correct answer.

The present trend in education is toward stricter educational accountability. Behavioral objectives help define some of the desired outcomes for which education can be accountable.

Student learning is not all at the same level. For example, direct recall of a fact requires fewer mental manipulations than applying a concept to a new situation. One system for indicating the level of difficulty of a desired response is through the use of Bloom's taxonomy. The higher the Bloom's number assigned to an objective, the higher the level of desired competence with a particular concept. Following are descriptions of Bloom's levels assigned to each objective.

Cognitive Objectives

Knowledge Level	Intellectual Level (Cognitive)
1.11 Knowledge of Terminology	2.10 Translation
1.12 Knowledge of Specific Facts	2.20 Interpretation
1.21 Knowledge of Convention	2.30 Extrapolation
1.22 Knowledge of Trends and Sequences	3.00 Application
1.23 Knowledge of Classifications and Categories	4.10 Analysis of Elements
1.24 Knowledge of Criteria	4.20 Analysis of Relationships
1.25 Knowledge of Methodology	
1.30 Knowledge of Universals and Abstractions in a field	
1.31 Knowledge of Principles and Generalizations	
1.32 Knowledge of Theories and Structures	

Affective Objectives

1.0 Receiving Level
- 1.1 Awareness
- 1.2 Willingness to Receive
- 1.3 Controlled or Selected Attention

2.0 Responding Level
- 2.1 Acquiescence in Responding
- 2.2 Willingness to Respond
- 2.3 Satisfaction in Response

3.0 Valuing Level
- 3.1 Acceptance of Value
- 3.2 Preference for a Value
- 3.3 Commitment

4.0 Organization Level
- 4.1 Conceptualization of a Value
- 4.2 Organization of a Value System

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Affective Objectives
(Continued)

The following behavioral objectives are intended to give teachers direction during the teaching of this unit. The behavioral objectives define only key concepts basic to the entire unit. They do not define all the learning experiences that will occur. The objectives will be revised as more student data becomes available. This data will provide the necessary information to calculate realistic criterion levels.

Please teach with the objectives, not the test questions in mind. For the knowledge level objectives, students are expected to know specific things. However, for the intellectual level objectives, students are expected to take knowledge, apply it to an unfamiliar situation, and determine the best answer. Teaching the test question turns a level 2, 3, or 4 test question into a level 1, or knowledge level question.

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Behavioral Objective Number	Test Question Number	Concept Tested	Bloom's Taxonomy Question Level	Pre - Post Growth Criterion	Activities Developing the Objectives
1		Attitude questions are answered completely and truthfully (as measured by a and b below). a) Ninety percent of all students will respond to each opinion question. b) No more than 10 percent of the students will use patterned responses to unit evaluation questions.	2.2a		all
2	59	Environmental Education Project Modules are worth studying. *Posttest question only.	3.2a	70%	all
3	37	All schools should teach more about the ways the environment affects people and people affect the environment.	3.2a	10%	all
4	1	Match the word "plies" with its description.	1.12c	40%	B,C,K
5	18	Select the most important function of carbon black in tire performance.	1.24c	35%	B,K
6	2	Select the production step which imprints the tread pattern on the tire.	1.22c	35%	B,K
7	19	Select the sequence used to combine tire parts into a tire.	1.22c	45%	B,K
8	3	From a set of four acts, select the one process to which tires are not subjected following their curing.	1.22c	50%	B,C,K
9	20	Identify "adhesion" with the role it plays in tire construction.	1.23c	40%	B,C,E,K
10	4	Select the step in tire manufacturing which causes the greatest change in physical properties of rubber.	1.24c	20%	B,C,E,K
11	21	From a set of four employee job classifications, select the one category which serves as an insurance policy for the company.	1.30c	35%	C,K

Behavioral Objective Number	Test Question Number	Concept Tested	Bloom's Taxonomy Question Level	Pre - Post Growth Criterion	Activities Developing the Objectives
12	5	From a description of the bead break-away test, select the best reason for performing it.	2.20c	45%	C,K
13	22	Identify a picture of the tire part tested by the plunger test.	2.20c	35%	C,K
14	6	From a description of the endurance test, select the best reason for performing it.	2.20c	35%	C,K
15	23	Select "thermal expansion" as the physical property causing changes in volume as substances become warm.	1.23c	20%	C,K
16	7	Given the graph of elastic strength for one rubber band, select the curve expected for two overlapping rubber bands.	2.30c	20%	D,K
17	24	Given a graph of elastic strength, select an interpretation which best summarizes the relationship between length increases and increasing mass.	2.10c	20%	D,K
18	8	Given the graph of the thermal expansion of aluminum, students shall be able to determine the values of the coordinates for a particular point on the graph.	1.25c	20%	D,K
19	25	Given a histogram displaying many measurements of the same object, select the "best" measurement.	1.24c	20%	E,K
20	9	Match the sketch of the test for adhesion with a description of the test.	1.25c	40%	E,K
21	26	Select a sentence summarizing the degree of governmental control of business in United States.	1.31c	30%	F,K
22	10	Select the most realistic proportions of Goodyear's income used for raw material purchases, labor costs, and profit.	1.23c	60%	F,K

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Behavioral Objective Number	Test Question Number	Concept Tested	Bloom's Taxonomy Question Level	Pre - Post Growth Criterion	Activities Developing the Objectives
23	27	Apply the definition of "capital" to select its use in business.	1.23c	25%	F,K
24	11	Given four possible results of adding pollution control equipment to a manufacturing plant, select the most realistic outcome.	1.31c	15%	F,K
25	28	Match the function with a description of Goodyear's sound enclosures.	1.25c	60%	G,K
26	12	Given a list of six options, select the four which will often cause hearing loss.	1.12c	35%	G,K
27	29	Select the maximum acceptable decible level for an 8 hour working day.	1.12c	60%	G,K
28	13	Given one decible level, select a level four times as loud.	3.00c	60%	G,K
29	34	The student will indicate buyer resistence to noisy machines.	3.1a	15%	G,K
30	30	Match the function with a description of one of Goodyear's dust collection machine.	1.25c	40%	H,K
31	35	Goodyear is meeting all state and federal laws on air, water, and noise pollution.	2.1a	45%	H,K
32	36	Before deciding to install pollution control equipment, the costs of both the equipment and the environmental damage should be considered.	1.2a	20%	H,K
33	14	Select a correct comparison of compressability and decay rates of tires with other materials found in trash.	1.23c	35%	I,K
34	31	Select the most promising method of disposing large quantities of old tires without causing environmental pollution.	1.25c	20%	I,J,K

Behavioral Objective Number	Test Question Number	Concept Tested	Bloom's Taxonomy Question Level	Pre - Post Growth Criterion	Activities Developing the Objectives
35	15	Select, from a set of four statements, the one best specifying the safety and potential recapped tires.	1.24c	40%	I,K
36	32	Tires do not easily decay.	1.12c	25%	I,K
37	16	Select "open dump" as an illegal method of disposing trash in Topeka.	1.12c	35%	J,K
38	33	Match "composting" with its description.	1.12c	20%	J,K
39	17	Select the method of solid waste disposal most likely to cause air pollution.	1.25c	20%	J,K

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CLASS PERFORMANCE SUMMARY SHEET

The following pages indicate how your class(es) responded to the pre and post-module tests. The following code is used throughout the test.

A - Percentage of students responding correctly on the pre-module test

B - Percentage of students responding correctly on the post-module test.

C - Percent growth expected between pre and post-module tests.

D - Phi score for the test item. This score shows the quality of the test questions. Phi scores below 25 indicate either a poor test item or a topic that was not taught well in the unit. Phi scores above 40 indicate a very good test item which was well taught.

The opinion questions have two scores listed for each test result. "+" scores indicate the percentage of students agreeing with the statement and "-" scores indicate those disagreeing. The students with no opinion make up the remaining and unreported percentage.

The correct answers are circled.

1. What is the name for the sheet of rubber with cords in it that is in the tire?

A ____ B ____

A. Tread B. Bead
C. Sidewall (D.) Ply

40% C ____ D ____

2. Where is the tread pattern placed on the tire?

A ____ B ____

A. Tread manufacturing machine
B. Tire building station
(C.) Tire curing press
D. Final inspection station

35% C ____ D ____

3. What is not done to tires after they have been cured?

A ____ B ____

(A.) They are run through the Banbury.
B. They have small pieces of rubber cut off their edges.
C. They are inspected to see if they are round.
D. They have rubber ground off to make the white sidewall.

50% C ____ D ____

4. What will cause a permanent change in many properties of tire rubber?

A ____ B ____

A. Stretching it until it breaks
(B.) Heating it for several minutes
C. Hitting it with sharp hammer blows
D. Running it through a mill to make it very thin

20% C ____ D ____

5. A large piece of steel is pushed against the white sidewall of the tire in a test which measures:

A ____ B ____

A. Tread thickness and elasticity
B. Ply strength and elasticity
C. Tread adhesion and endurance
(D.) Bead strength and adhesion

45% C ____ D ____

6. Tires are run against a metal fly wheel in a hot room to see:

A B

35%

C D

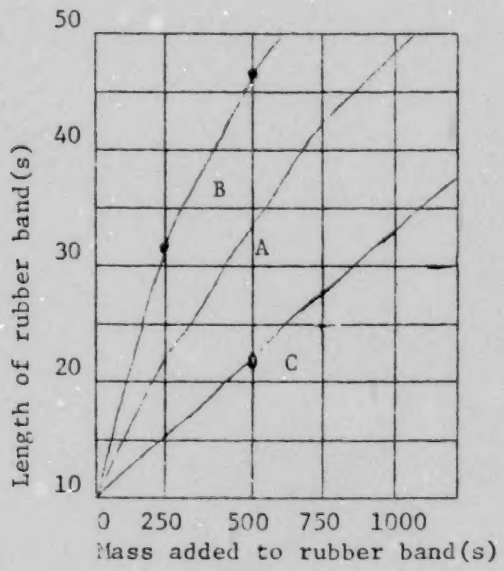
A. If the bead will hold to the wheel
B. How thick the tread is
(C.) If the tread stays on the tire and lasts as long as it should
D. How strong the tread and plies are

7. Line A is the graph of the rubber band shown in picture A. If picture Z shows the experiment used to measure the elasticity of two identical rubber bands, which graph should be the result?
A B (C)

A B

20%

C D



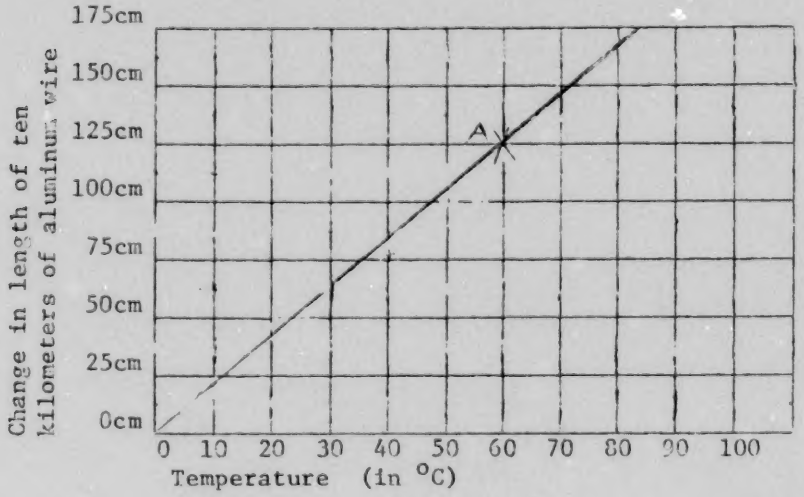
8. The graph below shows the thermal expansion of aluminum wire. What was the temperature and change in length of the wire at point A?

A. Change in Length = 55 cm
Temperature = 110° C
B. Change in Length = 150 cm
Temperature = 80° C
(C.) Change in Length = 125 cm
Temperature = 60° C
D. Cannot be determined from this graph.

A B

20%

C D

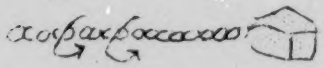


9. Which of the tests below would tell you if the different kinds of rubber will hold onto each other? An → means that the material is being moved in the direction of the arrow.

A.

B.

(C.)

D. 

10. Which line below best shows how the Goodyear corporation spends its income.

A. Raw materials 20% - Labor 45% - Profit 25%
B. Raw materials 25% - Labor 30% - Profit 35%
C. Raw materials 40% - Labor 35% - Profit 15%
(D.) Raw materials 50% - Labor 35% - Profit 5%

11. If prices don't rise, what will usually happen when pollution control equipment is added to a manufacturing plant?

A. Much better workers can be hired, and profits increase.
B. Profits will fall since the company's reputation is hurt.
(C.) Capital was not spent on production so profits will fall.
D. Profits will rise since the quality of products will rise.

12. Select the four choices below which can cause hearing loss.

A. 1,3,4,6 B. 2,4,5,6 C. 2,3,4,5 (D.) 1,3,4,5

1. Blows to the head.
2. High fat diets.
3. 100 decible noise, 8 hours daily.
4. Increasing age.
5. Disease affecting the nerves.
6. 50 decible noise, 12 hours daily.

13. Pick the decible level which is four times as loud as a 30 decible noise.

A. 40 (B.) 50 C. 60 D. 120

14. Choose the correct statements about tires in a landfill.

A. Tires will not pack tightly. They decay rapidly.
(B.) Tires will not pack tightly. They decay slowly.
C. Tires will pack tightly. They decay rapidly.
D. Tires will pack tightly. They decay slowly.

15. Which of these statements is correct?

A B
40%
C D

(A.) Recapped tires are required by law to be as safe as new tires.
B. Recapped tires can not be as safe as new tires.
C. Tires can be recapped several times.
D. Most of our new tires become recapped tires now.

16. Which way of getting rid of trash is illegal in Shawnee County?

A B
35%
C D

A. Landfill
(B.) Open dump
C. High temperature incineration
D. Composting

17. Which method of solid waste disposal will cause the most air pollution if not carefully regulated?

A B
20%
C D

A. Composting
B. Landfills
(C.) Incineration
D. Compacting

18. What is the most important reason for adding carbon black to tire rubber?

A B
35%
C D

A. It increases adhesion forces.
(B.) It increases wear resistance.
C. It increases elasticity.
D. It increases torsion and strength.

19. Which of the parts of the tire below are listed in the order that the tire builder puts them into the tire?

A B
45%
C D

A. Tread--plies--beads--inner liner
B. Plies--inner liner--beads--tread
(C.) Inner liner--plies--beads--tread
D. Inner liner--beads--plies--tread

20. What force holds tread rubber to the tire?

A B
40%
C D

A. Elasticity
B. Thermal expansion
C. Torsion expansion
(D.) Adhesion

21. Which one of these Goodyear employees acts as an insurance policy for the company?

A B
35%
C D

A. Banbury operator
B. Calender machine operator
(C.) Quality control lab technician
D. Tire builder

22. In the tire below, the strength of which part is tested by the plunger test?

A B
35%
C D

A (B) C D

A B 20% C D

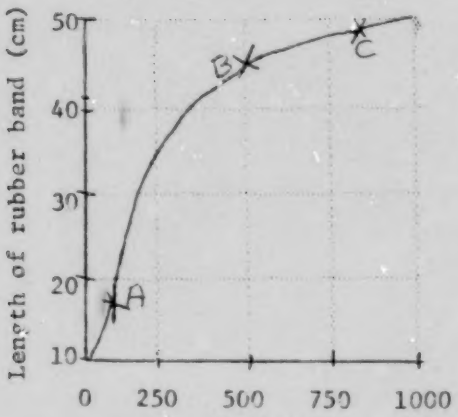
23. As a tire gets hot, some parts may change volume. What physical property causes this?

A. Torsion expansion B. Density
(C.) Thermal expansion D. Elasticity

A B 20% C D

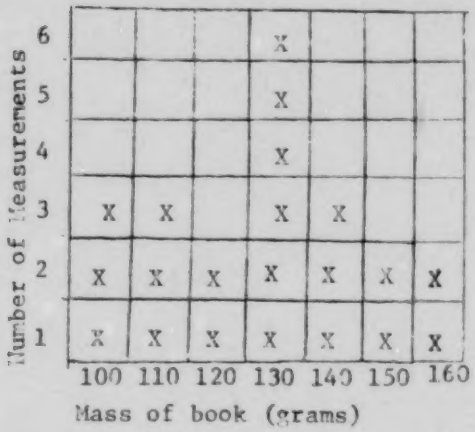
24. Which one of the following statements about the graph below is true?

A. An addition of 250 grams causes the greatest increase in length at point C.
B. An addition of 250 grams will stretch the rubber band about 20 cm at all three points on the graph.
(C.) An addition of 250 grams will cause the greatest increase in length at point A.
D. The rubber band at point A is weaker than the rubber band at point C.



25. If all the students in a class measured a book, and their results were placed on the histogram to the left, what is the best choice for the book's mass?

A B 20% C D



A. 6 gms
(B.) 130 gms
C. 120 gms
D. You can not answer this question without more information.

26. Select the most accurate summary of government and business relationships.

A. Government affects most decisions of large corporations.
B. Government affects few decisions of most businesses.
C. Taxes are the main tool used to control business.
D. Government controls small business more than large business.

27. A well-run business should use capital to:

A. Buy raw materials
B. Pay labor costs
C. Buy new equipment
D. Pay taxes and depreciation

28. Green wooden boxes are sometimes built around machines at Goodyear. What is the main purpose of the boxes?

A. Sound control
B. Dust control
C. Safety of workers
D. To hide secret processes

29. What is the maximum acceptable decible level for an eight hour work day?

A. 90
B. 80
C. 70
D. 60

30. What was the purpose of the large machine in a separate room? This machine scraped mud-colored material off of slowly turning paddles.

A. It was a dust collector
B. Automatic floor cleaner
C. It cleaned sewage water
D. It mixed tire chemicals

31. Which process may some day dispose of many millions of old tires while causing little environmental damage?

A. Producing ocean reefs
B. Making glasphalt
C. Burning tires to produce energy
D. Burying tires in landfills

32. Tires easily decay when left to rot above ground or in the water.

A. True
B. False

33. This method of getting rid of trash involves letting garbage rot so that it can be used as a fertilizer.

A. Incinerator
B. Landfill
C. Compacting
D. Composting

PART B

Your answers on the last part of this test will be used to determine what you think about some of the ideas discussed in the "Tire Production and Pollution Control" module.

Please use this code:

A. Yes (or I agree)
B. I'm not sure
C. No (or I disagree)

+A-	+B-	34. I think people should not purchase loud cars, lawn mowers, or vacuum cleaners if quiet ones are available.	A B C
+A-	+B-	35. I think Goodyear is probably meeting all federal laws on air, water, and noise pollution.	A B C
+A-	+B-	36. Companies should not need to purchase pollution control equipment unless their wastes are damaging human, animal, or plant health.	A B C
+A-	+B-	37. All schools should teach more about the ways the environment affects people and people affect the environment.	A B C
+A-	+B-	38. Laws requiring pollution controls should give old manufacturing plants a few years to meet new requirements.	A B C
+A-	+B-	39. Industries should be allowed to add pollution control costs to the costs of their products.	A B C
+A-	+B-	40. Private companies should be able to produce things as they wish without government interference.	A B C

PART C

Your answers to questions 30-57 will help us determine what you think of the module in general. Please use this key:

A = Yes (or I agree) B = I'm not sure C = No (or I disagree)

41. I think we had to go through this module too fast. A B C

+B-

42. I think our class discussions were interesting and informative. A B C

+B-

43. I think our substitute teacher was adequately prepared to present the material. (Mark D if you had no substitute.) A B C

+B-

44. My teacher helped answer most of my questions about ideas presented in this module. A B C

+B-

45. I think we used the self-test questions in a way that helped me learn and think. A B C

+B-

46. We discussed the films in a way that helped each of us learn and think. A B C

+B-

47. I think my teacher enjoyed teaching this module. A B C

+B-

48. I think most other students enjoyed studying this module. A B C

+B-

49. Most of the necessary papers and supplies were ready when we needed them. A B C

+B-

50. I think that most of the questions asked by this test were fair. A B C

+B-

51. I think the papers in this module contain useful and interesting information. A B C

+B-

52. I think the papers in the module could be easily read. A B C

+B-

53. I think the ideas covered in this module fit together pretty well. A B C

+B-

54. The films used in the module were interesting and useful. A B C

+B-

55. I enjoyed taking the trip, and I learned a lot. A B C

+B-

56. The trip leaders did a good job helping me learn on the trip. A B C

+B-

57. I discussed some of the things in this module with my family or friends. A B C

+B-

58. I think the activities and exercises in this module were interesting and useful. A B C

+B-

59. Overall, I think this module was well worth the time we spent studying it in class. A B C

+B-

60. I would like to study other modules developed by the Environmental Education Project. A B C

+B-

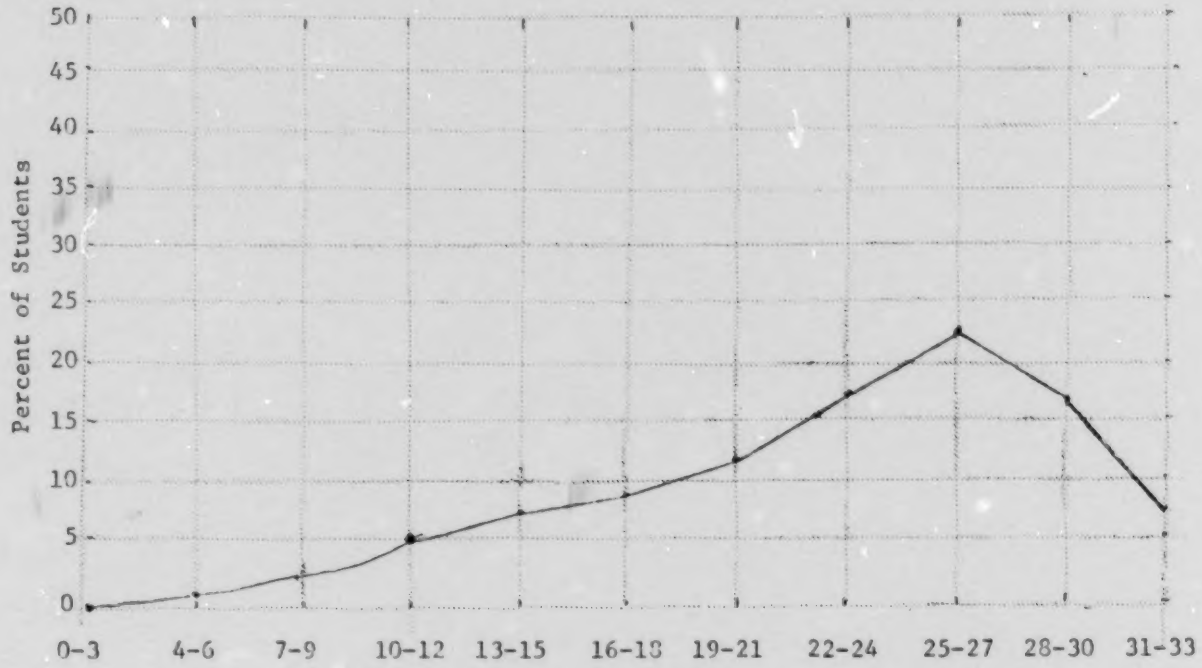
Percent of students answering the least answered attitude question_____.

Percent of students using patterned responses on the attitude questions_____.

Predicted City-Wide Mean = 22.5

Class Mean_____ Standard Deviation_____

Frequency Polygon (--- = pre, ——— = post, ——— = predicted city-wide post profile.)



Differences in Tire Designs

Tires for cars look pretty much the same, on the outside.* However, inside there are three basic types - conventional bias-plies, radial-plies, and belted-bias plies, and these types are different in many ways.

Basically, all tires are made up of three parts; the bead, the carcass and the tread. The bead is the edge of a tire that seals against the rim. The two beads are usually reinforced with steel cable which must pass strict stretching tests. The tread is the grooved part that touches the road. A re-tread is an old tire with new tread. The carcass is the body of the tire.

The oldest and most familiar type of tire in this country has been the bias-ply. (Figure A) Its carcass consists of layers of rayon, nylon, or a polyester rubber coated cord running at angles from one side of the tire to the other. A two-ply tire has two layers of cord, running at cross angles, a four-ply tire has four layers of cord. In general, these tires ride better, but have average or less stopping, and cornering, ability. They also wear out more quickly and tend to rupture (have a flat when hitting a sharp object) much more easily than the other two kinds of tires.

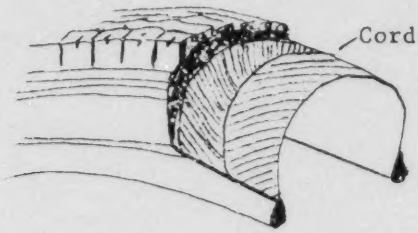


Figure A. Bias-ply Tire

The radial ply tires, on the other hand, have plies running at right angles to the tread. Then a belt of textile or steel is laid down under the tread and all the way around the tire (see Figure B). On the whole, these tires do not ride as comfortably as other tires and their stopping ability is only average. However, they corner, resist rupture, and wear much better than average.

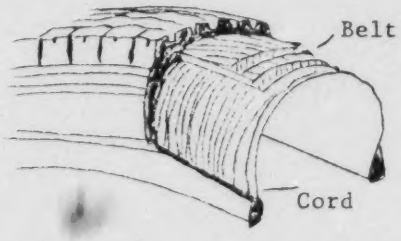


Figure B. Radial-Ply Tire

The third type of tire, the belted bias ply, has plys of rayon, nylon, or polyester running at cross angles to the tread, just like the old bias type (Figure C). However, it also has a belt around the wheel, like the radial type. This belt is often made of fiberglass. This type of tire has an average or above stopping ability and tread life, about average rupture resistance, and everywhere from above to below average cornering ability, depending on the tire.

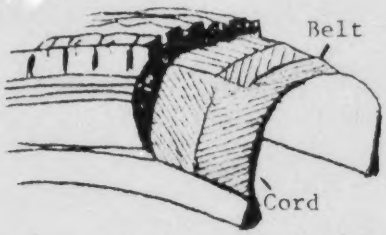


Figure C. Belted Bias Ply Tire

Finally, to get the best performance from any of these tires, you must keep the pressure at a correct level, for under-inflated and over-flated tires wear unevenly. Remember to check the tires when they are cold, and check them about once a month. Avoid 'burning rubber' with jack rabbit starts, for that just wears the tires out. Last, but not least, always drive with four tires of the same type. Never mix radial ply with bias ply or any other combination. Tires are like shoes, and each type has different handling characteristics on curves. Mixing types would be like playing basketball with a rubber soled shoe on one foot and a leather shoe on the other foot. When one shoe loses traction before the other, a dangerous slide can occur.

Student Self Test

1) What are the <u>differences</u> in construction for the bias-ply, radial ply, and belted bias ply tires?

2) How are the three types made the same?

TRASH - WHERE DOES IT GO?
(Four Experiments)

EXPERIMENT 1, COMPOSTING

When food, leaves, and organic materials are allowed to decay in a moist environment with soil, compost is made. Bacteria, yeast, and molds are small plants which cause these materials to decay. Protozoa and nematodes are small animals which speed decay. All of these plants and animals are found in soil and require moisture and organic material to live.

To set up a miniature compost garden, find a round metal can or plastic jar six to eight inches in diameter, and three or four inches deep. If you can't find a round container, use one that is square or rectangular.

Fill the bottom of the container with firmly packed layers of soil about one inch deep. Different members of your class should use soil from different areas such as: wooded areas, bare areas, and sand boxes.

Now supply material to be composted. Select food, paper, or cloth that you would normally throw away in your kitchen. You could use nutshells, stale bread, banana skins, apple cores, napkins, rubber, cellophane, paraffined paper, orange peels, breakfast food and so on. Do not include protein materials such as cheese, meat, or jello since these may cause unpleasant odors.

Use small pieces about 1 cm square and less than 0.5 cm thick. Place five of these on the surface of the soil as shown below:

Figure 1: Inside view of a compost test garden

Cover the container with a thin layer of transparent plastic or Saran Wrap; hold in place with a rubber band. Remove the cover every three or four days to allow more oxygen to reach the compost. Keep the soil moist, but not waterlogged. Be sure to label each glass.

Figure 2: Completed compost garden.

The most obvious development will be mold. They will be white, black, green, purple, orange, or almost any color. The colors are usually due to spores, which act as seeds for mold plants. Bacteria and yeast colonies may also form visible spots, but they will fill less space than molds. The protozoa and nematodes will be eating the plants. They may be seen with a microscope.

Keep a record of the appearance of each garden for at least a two week period. Observe these things: 1) Which materials decompose the fastest? 2) Which soils cause the most rapid decomposition? 3) Are there changes in the kinds and amounts of things growing in the compost gardens? 4) How do the odors change as time passes?

EXPERIMENT 2 - LANDFILLS

Landfills, like composting, involve soil and organic material. The difference is that the organic material is buried in landfills, and much less oxygen can reach it.

To make a miniature landfill, get a tall transparent glass or plastic container. Use the same soil and organic material that was used in the compost garden, but bury the material at different depths. Place each of the organic samples against a wall of the glass so that its decay can be seen. Leave about 2 cm of air space above the top of the soil. Keep the soil moist, but not wet and waterlogged. Cover each landfill with a tight cap of aluminum foil. Label each glass.

Figure 3: Your miniature landfill should look like this.

Keep a record of the landfills for at least two weeks. Observe at least these four things:

1) Which materials decompose the fastest?
2) Which soils cause the most rapid decomposition?
3) Are there changes in the kinds and amounts of things growing in the landfill?
4) Do the odors change as time passes?

EXPERIMENT 3 - WATERLOGGED LANDFILLS

Most molds require oxygen to decompose organic material. Many kinds of bacteria require no oxygen. A waterlogged landfill or a deep landfill will allow no oxygen to reach the organic material. This means bacteria are the major decomposers in landfills.

To make the equivalent of a waterlogged landfill, take a tall transparent glass. Fill it one-third full of soil. Different members of the class should add different ingredients to their landfill. You may add two heaping tablespoons of sugar, or corn starch, or gelatin, or add nothing at all. Now, pour water into each glass until it is three-fourths full of dirt, organic material, and water. Stir the mixture until it is a waterlogged mud.

Now add more water until the water level is within a centimeter of the top of the glass. Cap the glass with aluminum foil. Label each glass.

Keep a record of these landfills for at least two weeks. Make at least these observations:

1) Do you see any growth of plants of animals?
2) How do the odors of the four glasses compare?
3) Do the odors change from day to day?

EXPERIMENT 4 - METALS IN LANDFILLS

Many plant materials contain acid. When metals are placed in a moist landfill, the acids released from decomposing plants may affect the metal. Aspirin contains a weak acid which is a combination of acids found in vinegar and some types of bark. The acid is acetylsalicylic acid, and it breaks down in water to form the two natural acids, acetic acid and salicylic acid.

To observe the reaction of acid with metal, stir three aspirin tablets into a a nearly full glass of water. In different glasses, place small pieces of a steel wool, copper Brillo pads, an iron nail, a zinc coated iron nail, zinc, aluminum, and any other metals of interest. Add equal amounts of the same metals to water without the acid, so that the affects of the acid in water can be compared with the affects of water. Keep a record of your observations for about two weeks.

Observe at least these things:

1) Which metals react the most rapidly with aspirin and water?
2) Do small or large pieces of metal react more rapidly?
3) Does the reaction slow down after several days or hours?

STUDENT SELF TEST QUESTIONS

1) List two values and two disadvantages of composting all organic materials.

2) Why should landfills be built so that they do not become waterlogged?

3) What will happen to the surface of a landfill as its contents decompose?

4) Many metals are poisons if swallowed in large amounts. How could landfills affect town water supplies?

The Topeka Public and Parochial Schools
Unified School District No. 501
Environmental Education Demonstration Project

Introduction

The Environmental Education Project was created by the Topeka School Systems to help you learn about your environment. The project develops and tests materials for classroom and field trip activities. This module focuses on industry and the methods it uses to control pollution. It also examines your role in helping to create a better world for all of us.

The module is built around five main ideas:

1) Tires: Production methods and testing procedures.
2) Characteristic properties used to help make and test tires.
3) Economics: The costs of production and pollution control.
4) Causes and solutions for the ever growing trash problem.
5) Sound pollution: its causes and control.

The module also includes papers and activities about two other ideas which you and your teacher may choose to study and discuss.

1) Tire design and comparative values

2) Recycling: its role in our future.

Following your study of this module, your class will take a field trip to the Topeka Goodyear Plant and Lapeka Inc., the recycling center for aluminum cans.

The Environmental Education Project uses test results to determine what you learned from the module and what you think about different parts of it. You will be given tests over the module before and after you study it. The tests will be used to determine what changes should be made in the material. Whether or not the teacher grades you using these test results is a decision to be made by your teacher. Test questions will be drawn from student self-test questions with each paper.

All of your answers to the factual test questions will be reported to your teacher for use in grading, if requested. The test will also contain a set of questions about your opinions. Your answers to these questions will be used by the Environmental Education staff to improve the material you are studying.

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Green pages in the teacher's material usually will contain three sections:

1) "Topics and Concepts" - lists the ideas from the student papers and exercises that will be on the final test. The numbers of the topics correspond with the behavioral objectives listed in the front portion of this module.

2) "Teacher Suggestions" - provides background material and suggestions for presenting the paper or exercise.

3) "Answers to Student Self-Test Questions" - provides answers and follow-up material to help in a discussion and review of the self-test.

This introductory paper is concerned with the following three attitudes. They will be nurtured throughout the next two weeks as the students work with this module.

TOPICS AND CONCEPTS TESTED

1) Students should read each opinion question on the final test and try to respond truthfully.

2) Upon completion of this module, students should indicate a desire to study other modules developed by the Environmental Education Project.

3) Upon completion of this module, students should indicate a desire to study more material about man's relationship to his environment.

TEACHER SUGGESTIONS

Please bring out three points during the introduction:

1) This module is about the industries that play a very large role in everyone's life. The module focuses on Goodyear as an example of industry and teaches processes used at the plant. However, similar problems of solid waste control, sound pollution, financing, assembly line workmanship, and quality control testing exist in all industries - whether we talk about car or drug manufacturers.

2) The project is very interested in student and teacher opinions, criticisms, and compliments. We get these comments during the field trip, from teachers; verbal and written comments, and from opinion questions on the student test. Please encourage students to react to the material being presented. Pass their reactions and yours on to us.

3) You should make it clear if students will be graded using the factual part of the posttest. The tests are fair, and are strictly based on the behavioral objectives included in this module. If the students understand each paper's student self-test questions and the field trip material, they should do very well on the posttest.

Tires Aren't Just Hunks of Rubber

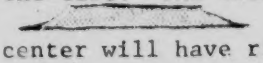
The Goodyear plant in Topeka makes many kinds of tires. Each tire has several parts, and each part of each type of tire is made of different combinations of materials. This paper describes the basic process used to make tires.

Passenger tire rubber is made from a combination of:

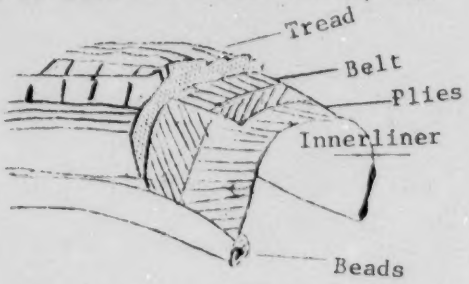
Rubber - About 25 percent natural rubber, which provides good elasticity and heat resistance.
About 75 percent synthetic rubber, which lasts longer than natural rubber and is cheaper and more easily obtained.

Chemicals - Sulfur helps cure rubber so that it becomes stronger, more elastic, and non-sticky.
Zinc oxide helps cure rubber and increases the adhesion between different tire layers.
Carbon black helps the rubber resist wear and makes the rubber black.
Titanium dioxide helps the rubber resist wear and makes the white sidewall rubber white.
Oils help keep the rubber flexible while the tires are manufactured.
Other chemicals control the way rubber cures and help keep rubber from hardening and cracking because of smog and oxygen in the air.

Passenger tires are built using four basic parts:

1) Tread rubber is the thickest part of the tire. The tread rubber is applied to the tire as a sheet with this shape  . The thin edges cover the sides of the tire, and the thick center will have ridges and hollows formed to make the tread design when the tire cures. Tread rubber is designed to be elastic and very resistant to wear, smog, oil, and gasoline. A white sidewall tire will have a thin strip of white rubber covered with black rubber placed on one side of the tread rubber. After the tire cures, the black rubber will be ground off to reveal the proper number and width of stripes.

2) Belts and plies are found under the tread. Plies and belts both are made of bands of cord coated with rubber. The cord may be wire, fiberglass, rayon, nylon, or polyester. The plies give the tire strength to resist rocks, holes, nails, and other road hazards. Plies are layered completely across the tire. Belts cover only the center of the tire to give strength at the most important area. Plies and belts are always used in pairs so that the cords overlap and provide maximum strength in all directions.



3) The innerliner is a soft, thin, very flexible layer of rubber found on the inside of the tire. It helps seal the tire to the metal wheel and helps resist puncture by small, sharp objects, such as nails and thorns. Its main use is to keep air contained between the metal wheel and the tire.

4) The beads are rings of wire around the inside edges of the tire. The beads keep the tire round and keep the tire from pulling away from the wheel when sharp turns or curbs put strain on the side of the tire. Without the bead, the tire would pull away from the wheel when the tire was inflated.

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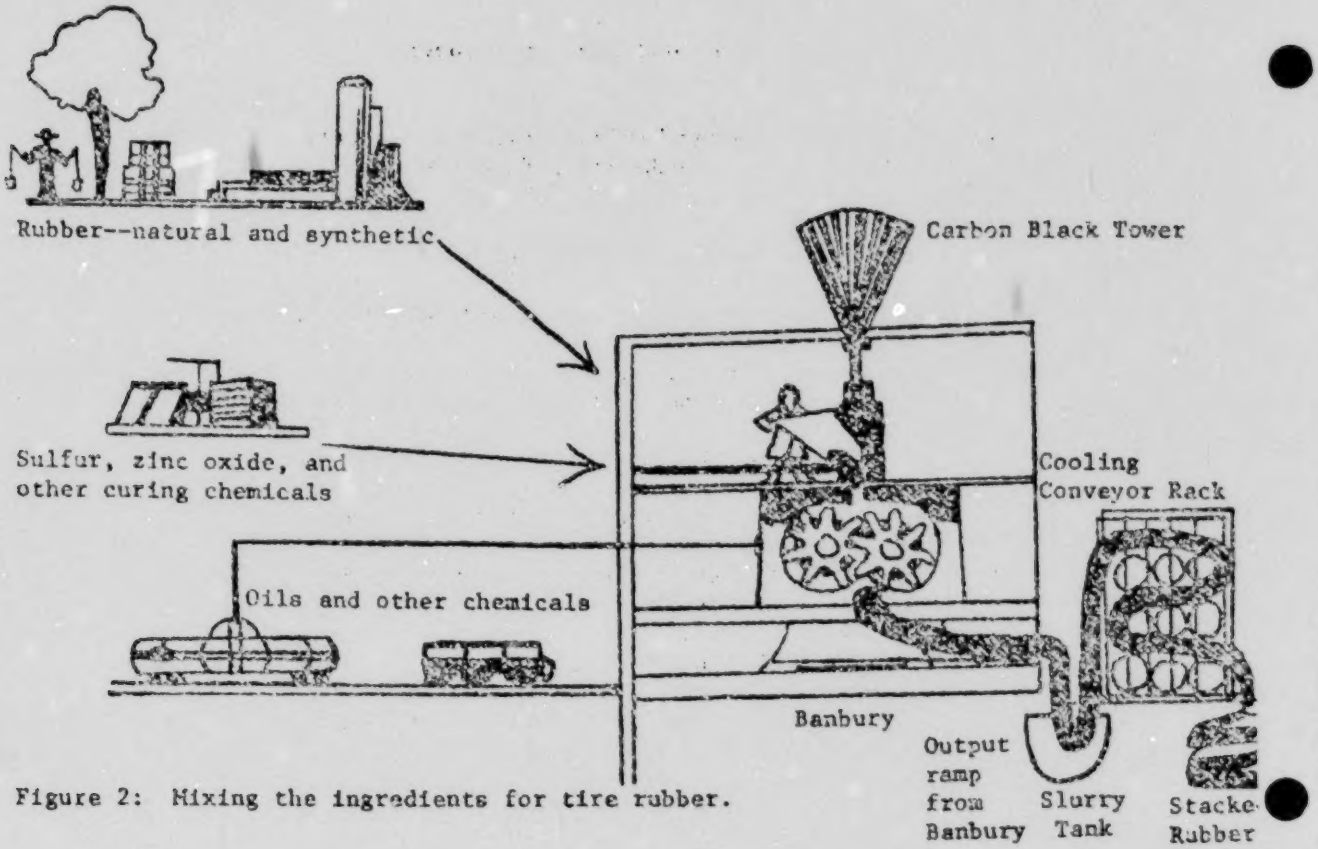

Figure 2: Mixing the ingredients for tire rubber.

Mixing Large Batches of Rubber

The actual tire rubber is mixed in 12 large Banbury machines on the second floor of the Goodyear building we will visit. The Banbury machines resemble a blender. Paddles whip the pieces of rubber and other chemicals against the side of the machine, while a large ram forces the rubber against the paddles. The tremendous force of the paddles causes the rubber to heat up to about 150° C in just a few minutes. The length of time the materials are mixed and the mixing temperature are watched very carefully. Too much or too little time or the wrong temperature will produce a bad batch of rubber. The heat is caused by friction of the paddles against the rubber and the machines must be cooled to avoid too much of this heat. These machines can make 200-500 kilograms of rubber at each mixing.

After the rubber has reached the right temperature and has been mixed the right length of time, it is forced out of the Banbury onto a conveyor belt. The belt carries a 20-25 meter strip of rubber through a slurry tank filled with water and a white material called soapstone. The soapstone coats the uncured rubber and keeps it from sticking to other layers of rubber. The coated rubber is cut and stacked for later use.

Some of the newest Banbury machines force the rubber through holes to form ropes of rubber which are cut into pieces. These pieces of rubber form golf-ball sized rubber pellets which can be easily handled and measured. These pellets are also coated with soapstone.

Many kinds of rubber mixtures are made in the Banburies. The mixed but uncured rubber is sent to a variety of machines to make the many materials used in Goodyear.

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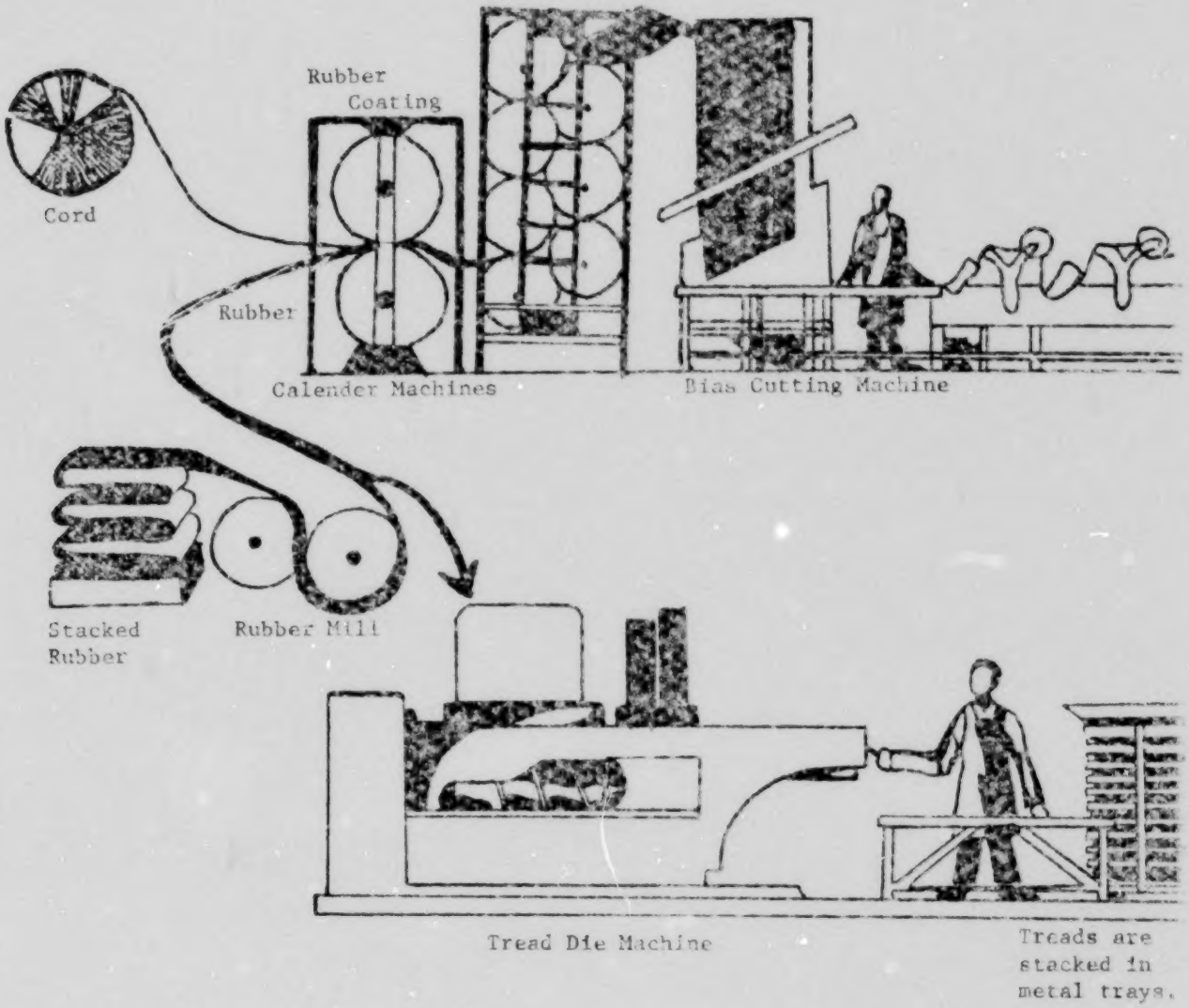


Figure 3: Making treads and plies from cord and milled rubber.

Forming the Tire Parts From Rubber

After the Banbury rubber is tested and released for use, it is run through mills, or giant rollers which squash it into thin sheets. From here the rubber goes several different routes before reaching the tire.

Tread rubber, for instance, is a very tough and thick rubber layer that is forced through a die to make a sheet of rubber the correct shape and length for each tire. The treads are coated on one side with a very sticky rubber to increase adhesion to the plies which will lie below the tread in the tire.

Some of the Banbury rubber travels to the calender machine, where wide bands of cords (which may be made of steel or fabric) are coated on both sides with rubber. These fabric-coated bands will become the plies and belts which give the tire body strength and the ability to resist cuts. The bands for most tires are cut on an angle, or bias, so that they can be crisscrossed to provide maximum strength in the tire. Radial tires use plies which run straight across the tires and belts whose cords are straight around the tires.

Other rubber is turned into the white sidewalls and innerliners which act as inner tubes for tubeless tires.

Preparing Other Tire Materials

The fabric used in plies and belts must be coated with liquid latex before tire rubber can stick to it. After the fabric is soaked in latex, it is given the 3-T treatment of time, temperature, and tension. By stretching the threads for a certain time at the correct tension, the fabric will have the proper strength and elasticity for the tire. The treated fabric and steel fabric wire bands are then sent to the calender machine for rubber coating.

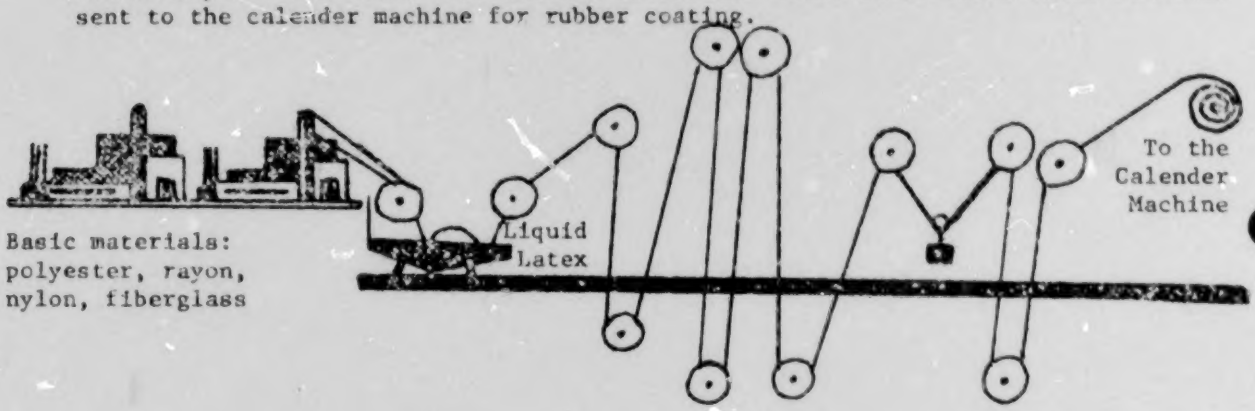


Figure 4: Goodyear's 3-T Process:
Fabric is coated, stretched, and heated to increase its strength.

Wire called beadwire is also used to make tires. Fifteen to 20 pieces of this wire are coated with rubber, then wrapped into a ring. The ring is placed around the edge of each tire. The tire rubber is then wrapped around the bead and sealed.

Building and Curing the Tire

After the various parts of the tire are ready, a tire builder starts putting the tire together on an inflatable barrel.

1) The first layer of very flexible rubber makes the innerliner for the tire.
2) Ply layers of cord and rubber are laid over the innerliner in the proper directions.
3) Bead wire rings are placed on the plies near the edges of the tire.
4) The plies are folded back over the beads so that the beads are surrounded by plies.
5) Then the thick tread rubber, with its sticky inner-coating, is wrapped around the tire.
6) White sidewall rubber is laid on one edge of the tire, and the barrel deflates so that the tire can be removed.
7) The tire is then sent to the curing presses.

Now the whole tire is placed in a mold in a curing press. In the curing press it is heated and cured under pressure. The tread and tire shape are made by the mold as the soft heated rubber is forced into the cracks and around the ridges of the mold. After the rubber has cured, it will be stronger, non-sticky, and will retain its shape and flexibility in all weather. Curing is like baking a cake. After the tire rubber is heated, its characteristic properties are drastically changed.

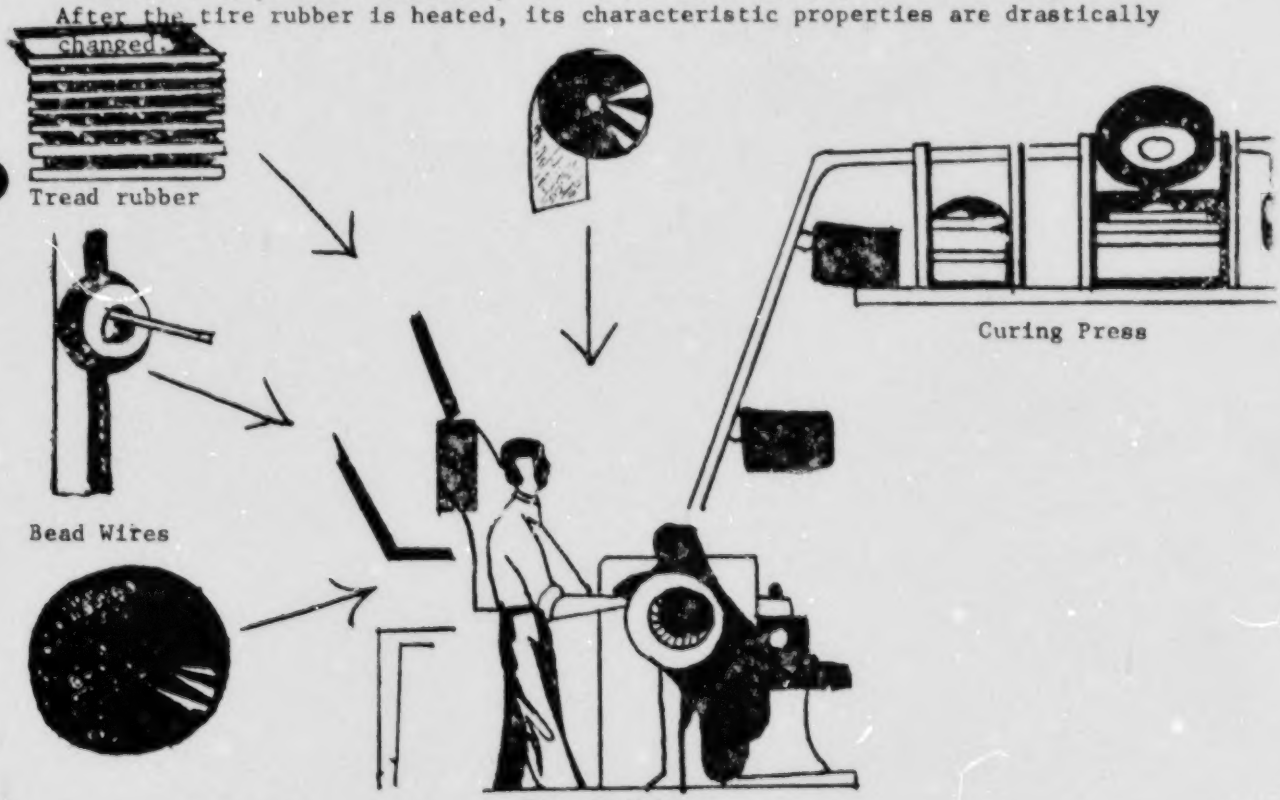
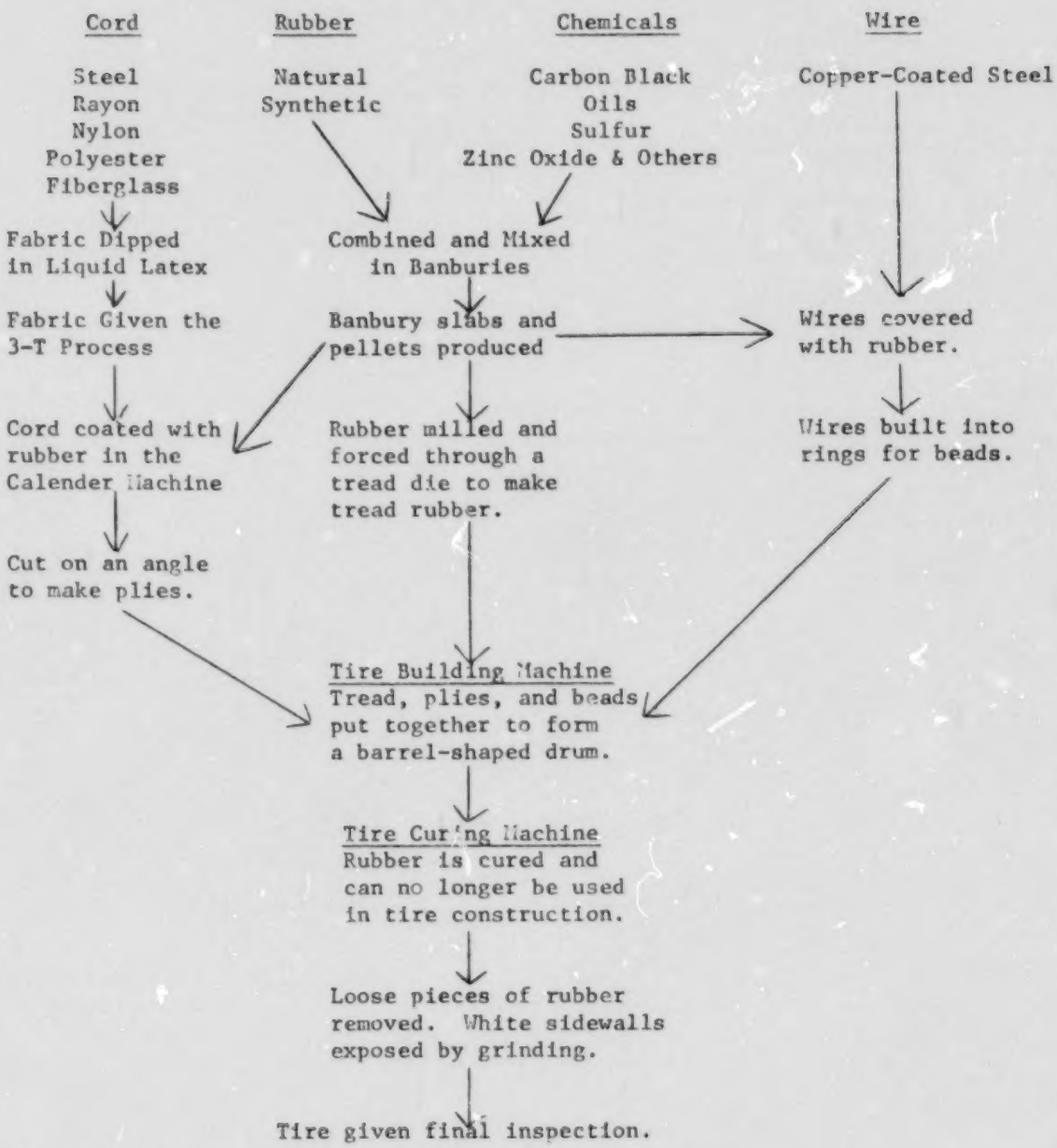


Figure 5: Building and Curing the Tire

Preparing the Tire for Market

When the tire comes from the mold, men clean off most pieces of loose rubber, grind off the thin layer of rubber over the white sidewall if the tire has one, and carefully check the tire to make sure it is free of defects. Samples of some of the tires are X-rayed to make sure that there are no blisters or cracks in the cords or between the layers which cannot be seen.

Flow Chart for Goodyear Tire Production



Student Self-Test Questions

1) Describe the method used to turn sticky, weak, and soft, barrel-shaped tires into strong, non-sticky, wear resistant tires. Name two chemicals which help this process.

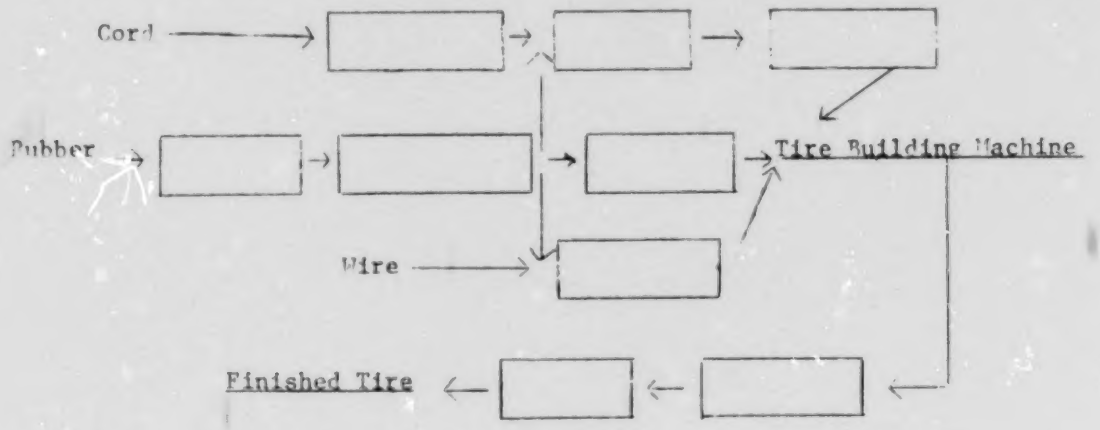
2) Which parts of a tire give it the properties listed below?

Tire Parts: a) Tread; b) Plies and Belts; c) Innerliner; d) Beads

Tire Properties	Tire Parts
1) Resists roadwear	_____
2) Holds to the road	_____
3) Holds to the wheel	_____ _____
4) Resists puncture by nails	_____ _____ _____
5) Resists tears from holes in the road.	_____

3) Ten machines are important in making tires. Place the machines in the proper sequence in the diagram below.

Machines: Banbury, Bias Cutting, 3-T Processing, Curing Press, Bead Wrapper, Tread Die, Mill, Sidewall Grinder, Calender Machines, Tire Building Machine.



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Behavioral Objective Numbers	Topics and Concepts
4	Students should be able to match the word "plies" with its description.
5	Students should be able to select the most important function of carbon black in tire performance.
6	Students should be able to select the step which imprints the tread pattern on the tire during the tire production process.
7	Students should be able to select the sequence followed while combining tire parts into the tire.
8	Students should be able to select the one process, from a set of four acts, to which tires are not subjected following their curing.
9	Students should be able to identify "adhesion" with the role it plays in tire construction.
10	Students should be able to select the step in tire manufacturing which causes the greatest change in physical properties of rubber.

Teacher Suggestions

Presenting Paper B:

Page B-7 should be duplicated for classroom use with this paper.

The material in this paper is designed to introduce students to the production methods used at Goodyear. Most terms which will be used during the field trip are introduced in this paper and reinforced with the slide-tape presentation, "Manufacturing at Goodyear," and the two tire production display boards. The student self-test questions and suggested discussion material for the teacher will help meet the behavioral objectives and will help students begin to feel comfortable with the new vocabulary.

The following outline was used in writing this paper.

A. Materials used in mixing tire rubber

B. Basic components of tires

C. Preparing tire components

1. Mixing rubber

2. Rubber's use in tire components
   a. Treads
   b. Plies
   c. Sidewalls and innerliners

3. Preparing other tire materials
   a. Fabric
   b. Beadwire

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D. Preparing the tire for market

1. Building

2. Curing

3. Preparation

The outline presents first the center, then the two sides, and then the lower third of the flow chart displayed on page six.

Students can best answer the student self-test questions if they read the paper once, watch the slide-tape presentation, then re-read the paper while answering the questions. As they read the paper, they should be encouraged to refer to the tire production display boards and the flow chart on page B-6.

Presenting the slide-tape series "Manufacturing at Goodyear"

The script to this series is included in the appendix to this module. The tape has a five-second pause between each slide description. Interrupt the tape to question your class whenever convenient. The questions below should help students review the basic functions of the men they will observe on their field trip.

How do each of these men help produce a new tire?

A. Banbury operator
B. Calender Machine Operator
C. Curing Press Operator
D. Quality Control Lab Technician
E. Tire Builder

Answer:

A. The Banbury operator mixes the many kinds of rubber needed for different parts of the tire.
B. The Calender Machine Operator coats the fabric with rubber. This becomes the plies.
C. The Curing Press Operator heats the uncured rubber to produce the finished tire.
D. The Quality Control Lab Technician checks samples of rubber and chemicals before releasing the uncured rubber for use in the tire.
E. The Tire Builder places the many parts of the tire together.

An optional demonstration: Extracting rubber from latex

Fifteen ml's of liquid latex per class have been supplied by Mr. Martin, the science supervisor. If a portion of this latex is slowly poured into a beaker containing vinegar or acetic acid, the latex will quickly coagulate. Two separate "pourings" per class should be made. Form one mass into a ball of natural rubber and the other into a ribbon. (NOTE THE PRECAUTION ON PAGE 10!) This process is analogous to the methods used to make natural rubber. Sap from rubber trees is mixed with vinegar and the coagulant is shaped into sheets which are then baled.

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One precaution should be observed when forming the rubber ball or ribbon: initial squeezing of the newly formed rubber may squirt liquid latex for several feet. The latex forms a gum which is quite difficult to remove from clothing and hair. We would recommend "massaging" the newly formed rubber inside a sheet of note paper, then returning it to the acid bath one more time. Lab aprons may also be used.

Students should note the differences between natural rubber and tire rubber. The following questions could be used effectively.

1. Why is most tire rubber black, when natural rubber and most synthetic rubber is not black?

Answer:

Rubber will rub off easily, just like an eraser. Carbon black or titanium dioxide is mixed with the rubber to greatly increase its wear resistance. Carbon black mades the rubber black. Titanium dioxide is more expensive and is used in making white sidewall rubber.

2. Natural rubber is weak (a thin piece is easily pulled apart); not very elastic (it will not stretch far, and will not retain its shape); and it becomes sticky when heated (quick heating in a disposable container over a Bunsen burner will demonstrate this property). How are these properties changed to make tire rubber?

Answer:

The rubber is mixed with sulfur, zinc oxide, and other chemicals, heated for a few minutes; and slowly cooled. The rubber is changed chemically and assumes new properties. It is this step which greatly increases the adhesion between the different layers of the tire.

Save the natural rubber for later use with Paper C.

Student Self-Test Questions

Q 1) Describe the method used to turn sticky, weak, and soft, barrel-shaped tires into strong, non-sticky, wear-resistant tires. Name two chemicals which help this process.

A The tires are squeezed into a heated mold. Pressure inside the tire forces its tread against a metal mold. The pattern on the mold is imprinted on the tire, and the heat cures the rubber so that its shape is "set." Sulfur and zinc oxide are two key chemicals which help cure the rubber.

Q 2) Which parts of a tire give it the properties listed below?

Tire Parts: a) Tread b) Plies and Belts c) Innerliner d) Beads

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Tire Properties	Tire Parts		
1) Resists roadwear	Tread		
2) Holds to the road	Tread		
3) Holds to the wheel	Innerliner	Beads	
4) Resists puncture by nails	Tread	Plies and Belts	Innerliner
5) Resists tears from holes in the road.	Plies and Belts		

Follow-up Questions:

What chemical helps treads resist road wear?

Carbon black

How are plies and belts made differently from treads?

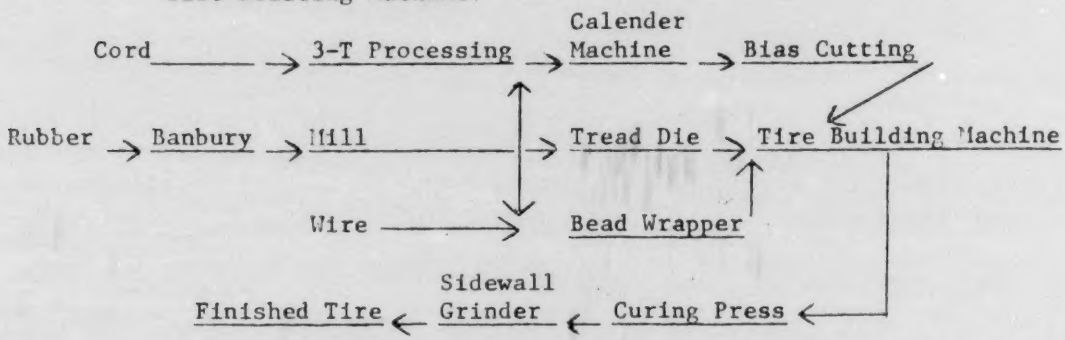
Plies and belts have fabric in them, which greatly increases their strength.

Why do beads help the tire stay on the wheel?

Beads contain rubber-coated wire rings which keep the inner edge of the tire round and the right size for the wheels. (The innerliner helps seal the bead to the wheel.)

Q 3) Ten machines are important in making tires. Place the machines in the proper sequence in the diagram below.

Machines: Banbury, Bias Cutting, 3-T Processing, Curing Press, Bead Wrapper, Tread Die, Mill, Sidewall Grinder, Calender Machines, Tire Building Machine.



Follow-up Question: What sequence is used for placing the tire parts together on the tire-building machine?

Innerliner - plies - belts - beads - tread - white sidewalls.

Controlling Tire Quality

Goodyear has thousands of employees and they make thousands of tires daily. Each type of tire is made from different materials. Each type of rubber, cord, or wire has different properties. When thousands of men work with hundreds of different parts, then much effort must be spent to make very sure that every tire is made exactly the way its designer intended for it to be made. This paper describes some of the many checks which protect the quality of each Goodyear tire.

Material Testing - Quality Control Lab.

Every new shipment of anything (whether it's sulfur, carbon black, or tire molds) is very carefully checked to make sure that it is what was ordered. Chemists make sure that the material is chemically correct. The material is checked to make sure that it is physically correct. New rubber and chemicals are mixed with standard samples to make sure that they mix properly and that the combination has the correct properties.

As just one example of this testing, samples of steel wire used in beads and belts must pass the following tests:

1) The copper coating on the steel wire is dissolved and the amount of copper is measured. (Chemical Test)
2) The thickness of the wire is carefully measured. (A Physical Test)
3) The wire is twisted until it breaks. A short piece of wire used in passenger tire beads must be twisted over 60 times without breaking. (This test of torsion strength is a physical test.)
4) The wire is stretched to have its elasticity measured. (A Physical Test)
5) The wire is cured in a block of rubber, and its adhesion to the rubber is determined by measuring the force needed to pull the wire out of the rubber. (A Physical Test)

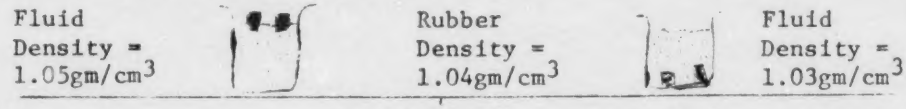
If the wire does not meet quality standards on <u>any</u> of these tests, the whole shipment is rejected and a new supply ordered. Only after passing every test is the wire released for use in the plant.

Every ingredient from zinc oxide to natural rubber receives careful study using several tests before it can be used. These tests serve as an insurance policy for the company by making sure that thousands of dollars are not lost by mixing the wrong ingredients.

Testing Mixed Materials

Once the lab has checked the raw materials, their work is not finished. Every new batch of mixed rubber, bead wire, or ply stock (rubber coated cords) must be checked before it can be used in the tire. Samples of every batch of rubber released from the Banburies is cured into rings and flat sheets. The rings are stretched and their elasticity is determined by measuring the force required to pull the rubber a measured distance. The flat sheets are cut up into tiny pieces and placed in cups of fluid with different densities. By seeing which fluids let the rubber float and which let it sink, the density of the rubber can be determined. Every kind of rubber must meet exact specifications.

Elasticity Test



Density Test

Other specialized tests given to some samples of tire materials are described below.

A) Elasticity--a single sheet of rubber is carefully stretched to see how much pull is needed to stretch it a certain distance.

B) Adhesion--the rubber is tested to see how well it holds onto the fabric cords or wire that will be in the tire. Different kinds of rubber, rubber and wire, and rubber and fabric must all adhere very strongly if a tire is to give good service.

C) Rebound--a block of rubber is hit with a weight, and the distance the weight bounces back is measured.

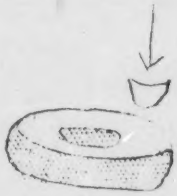
D) Thermal expansion--the threads of fiberglass, nylon, rayon, or polyester are heated in an oven to see how much they change length during heating and cooling. If the thread changes length too much as the temperature changes, it will be rejected since it would not keep its shape when the tire warmed up during use. The thermal expansion test is given to fabric samples before and after the 3-T process is used.

Testing Tire Samples

Every tire is examined after its parts are together but before it is cured. Incorrectly built tires are repaired before the tire is placed in the mold of the curing press. After the tire is cured, inspectors carefully examine every tire for over 100 different possible defects. These defects could range from beads that were not round to thin innerliners and pieces of tread formed improperly. Tires with minor defects are repaired if possible and sold as "blemished" or "second" tires. Tires with defects that cannot be repaired are thrown away.

Some tires are given much more stringent tests than the tires which will be sold. The first tires of every new tire design, and one out of every 10,000 tires after that, are tested with the tests described below. In addition, the U. S. Government also samples the tires and runs independent checks on their quality. These tests are:

1) The Bead-Breakaway Test--A heavy piece of metal shaped to fit beside the tire rim is pushed against an inflated tire. A machine reads how much pressure is needed to pull the bead away from the metal wheel. If too little pressure is required, the tire might go flat when you hit a curb with the side of your tire while turning.



2) The Plunger Test--A steel shaft is used to break the cords of an inflated tire to see how much pressure was required. If the tire fails this test, you could easily have a blowout when hitting a rock.

3) The Endurance Test--A tire is mounted on a wheel, then run against a smooth, metal flywheel at 50 miles per hour for 34 hours. This produces friction which heats up the tire and may damage the tread in poorly made tires. If the tire passes inspection after the 50 miles per hour test, it is warmed up again at 50 miles per hour for two hours, then run at 75, 80, and 85 miles per hour for 30 minutes at a time. It is carefully checked again after each of these runs.

Tires are also X-rayed and carefully measured to determine if all internal parts are correctly positioned.

Summary

All in all, making tires is a complicated business. Each piece of rubber and fabric in the tire must be able to glue itself to every other kind of rubber, all must have the same expansion and contraction properties with heat, and the tire must be durable, economical, and safe. If it is not durable or safe, the company will lose customers and the U. S. Government might make it call back every tire of a particular kind. If it is not economical, it will not sell well.

Student Self-Test

1. Suggest one thing that might happen to a tire if materials which flunked the tests below were used to make the tire. Suggest one result for each flunked test.

   a) Density
   b) Adhesion
   c) Torsion
   d) Elasticity
   e) Rebound
   f) Thermal Expansion

2. The tire has four basic parts: (beads, plies and belts, tread, and innerliner). Which of the tire parts are tested by each of the tests below?

   a) Bead Break-Away
   b) Plunger
   c) Endurance

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Behavioral Objective Numbers	Topics and Concepts
4	Students shall be able to match the word "plies" with its description.
8	From a set of four acts, select the one process to which tires are not subjected following their curing.
9	Identify "adhesion" with the role it plays in tire construction.
10	Select the step in tire manufacturing which causes the greatest change in the physical properties of rubber.
11	Students shall be able to select the one category, from a set of four employee job classifications, which serves as an insurance policy for the company.
12	Students shall be able to select the best reason for performing a bead break-away test from a description of the test.
13	Students shall be able to identify a picture of the portion of the tire which is torn during the plunger test.
14	Students shall be able to select the reason for performing the endurance test from a description of the test.
15	Students shall be able to select "thermal expansion" as the physical property causing changes in volume as substances become warm.

Teacher Suggestions

The tape-slide presentation, "Manufacturing at Goodyear," includes an introduction to the quality control methods used in Goodyear. Two broad concepts should guide the discussion of this paper: A) why is quality control needed? and B) How are the characteristic properties of matter utilized in constructing safe tires?

Students will understand the need for continuous quality control checks if the analogy is drawn between student reliability on experiments and the workmanship of 4,000 people making 1,200 different kinds of tires over a year's time. Mistakes do happen. The important thing is that everything possible is done to control mistakes and that they are caught whenever they do occur.

Several cured rings of tire rubber may be obtained from the Environmental Education office. Comparing these rings with rubber bands and the ribbons of natural rubber will help demonstrate and review several concepts about the physical properties of rubber.

Background for the Quality Control Lab Tests

Density: Goodyear determines the density of every batch of Banbury rubber. The density indicates whether the correct ingredients were included to enable the rubber to cure properly. To demonstrate a quick method of determining density,

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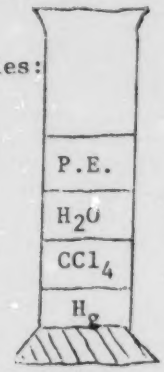
toss the three pieces of rubber into a beaker of water. The tire rubber will sink, but the other two will float. (NOTE - if the tire rubber ring is laid on the surface of the water, enough air may be trapped to suspend it. Make sure that each sample is delivered well below the water surface, then watch to see if they rise or fall.)

Ask the students why the tire rubber is denser. (It contains many chemicals and has been cured under heat and pressure. Curing makes a new material as sulfur combines with the rubber and drives out air bubbles. This increases rubber's density.

If table salt is stirred into the water, its density increases and the tire rubber will float. An addition of 20 grams of salt to 100 ml of water should float any rubber ring, since their density is usually less than 1.2 gm/cm^3.

If you can find the materials, the following demonstration would be quite interesting.

The following is taken from the New Jersey Science Teachers Association Newsletter, October, 1973.



"In a cylinder, add four immiscible liquids with different specific gravities: mercury, carbon tetrachloride, water, petroleum ether - in that order. (Be very careful with these chemicals. Use only as a demonstration.)

"Add a pinch of methyl red powder, if you wish, to color the liquid. DO NOT SHAKE, SINCE LAYERS OF PETROLEUM ETHER AND CARBON TETRACHLORIDE WILL MIX.

"Show that wood, cork, iron nuts, and other materials will sink to different levels because of their different specific gravities."

Adhesion is a measure of force of attraction between two materials. Uncured rubber which has been heated (in Banburies or mills) is quite sticky, and adheres well to many substances. Because of this adhesion, Goodyear must keep their rubber coated with soapstone or separated from other batches of rubber by metal or cloth dividers. Curing the rubber (which must be done with careful attention to the temperature and time) causes strong adhesive bonds to form and removes the rubber's tendency to stick to new substances. Heating rubber (cured or uncured) to 200°C will create a sticky surface which will last until the rubber oxidizes.

You may wish to assign the optional experiment (Paper E) on adhesion, if you wish to follow-up this discussion.

The torsion of an object is an indication of the amount of twisting which it can withstand. Bead wires are continuously twisted by very small amounts as the tire tread moves to the right or left on curves and the sides of the tire move in and out as the wheel rolls. To insure the wire's ability to make these small but very frequent shifts, Goodyear twists the wire until it breaks. Wires with sufficiently high torsion properties must be able to withstand 60, 360° twists over a 20 cm length.

Elasticity: Elasticity is the property of matter that requires a force to produce distortion and causes it to resume its original shape when the force is removed. Of the three rubber samples, the cured tire rubber ring is the most elastic, since

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it will return to its original shape after bearing a strong force. The rubber band will not resume its original shape as well. This can be shown by measuring the length of the band before and after stretching it nearly to the breaking point. The natural rubber ribbon will show significant distortion.

(NOTE: Elastic Modulus is a measure of the force required to produce a measured amount of distortion. The elastic modulus is determined by the two "elasticity" tests used in the quality control laboratory. Our guides will use the term "elastic strength" to describe the tests for "elastic modulus" during the field trip.)

The experiment on elasticity (Paper D) will provide a good review of both the elastic "strength" and the elasticity of rubber bands.

Rebound is a measure of the rubber's "bounciness." The natural rubber ball will have good rebound properties. Tire rubber would have much less, since most of the air pockets which help provide rebound properties have been removed. If too much rebound was provided by tire rubber, loss of traction would easily occur on bumpy roads.

Thermal Expansion: Most materials expand when heated and return to their original shape when cooled. Thermal expansion is the property which makes thermometers and thermostats function correctly, and it helps explain why hot air rises and cold air sinks. However, one material used in tires shrinks to less than its original size after heating. Nylon, rayon, fiberglass, and polyester fibers all shrink (like wool) after being heated. Therefore, Goodyear must "pre-shrink" these fabrics through the application of heat in the 3-T (time, temperature, and tension) process. Following application of the 3-T process, each roll of fabric is sampled to make sure that its new thermal expansion properties will be compatible with those of the rubber which surrounds it in the tire.

Background for the Whole-Tire Tests

The first tires of every new design are given careful tests before the line can be released for sale. These tests are required by the Department of Transportation, by the auto makers which buy many of the tires produced by Goodyear, and by Goodyear. After the initial tires have passed their tests, periodic samples are tested to insure the continued quality of the tires.

In discussing these tests on the trip, guides will focus on the relationship between the six physical properties discussed earlier and the tire's ability to pass its test. The relationships are summarized below.

1) The Bead Break-Away Test measures the adhesion of the tire to the wheel and the ability of the bead to resist the torsion forces which would turn and pull it from the wheel.

2) The Plunger Test measures the elastic "strength" of the cords as the plunger presses until the cords break. The distance the plunger sinks into the tire (before breakage) is measured and used in determining the fitness of the tire.

3) The Endurance Test measures the adhesion of the tread to the carcass, the elasticity of the tire as it flexes in and out during the run, and the effect

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of high heat on the different kinds of rubber, fabric, and metal. If differences in the thermal expansion of these materials exceeds the adhesive forces holding them together, the tire may rupture. If the rubber's density was incorrect, this would affect this test, since poorly made rubber would not have the correct physical properties. Sample tires are also X-rayed to determine the quality of workmanship which goes into their production.

Student Self-Test Questions

Q 1. Suggest one thing which might happen to a tire if materials which flunked the tests below were used to make the tire. Suggest one result for each flunked test.

a) Density
b) Adhesion
c) Torsion
d) Elasticity
e) Rebound
f) Thermal Expansion

A Density - Incorrectly made rubber has the wrong density. Therefore, if the rubber flunked its density test, it will not cure correctly and will weaken the tire.

Adhesion - Tread rubber would fly off the plies and plies would separate from the beads if adhesion is low. High adhesion won't harm anything.

Torsion - The beads will bend and twist as the tire bends from side to side. The rubber will soon begin to tear away from the beads, and the beads may begin to break if the wire has a low torsion tolerance.

Elasticity - Tires would give a rougher ride; rubber would split more frequently and sharp rocks could puncture the tire easier with rubber or fabric of low elastic strength.

Rebound - Tires would give a soft and bouncy ride when made of rubber with too much rebound. Bouncy tires could cause control problems. With too little rebound, the tires will give a rough ride.

Thermal Expansion - If all materials in the tire do not hold similar thermal expansion properties, then as the tire gets hot, the rubber may expand at a much different rate than the fabric or wire. This will cause the tire to weaken.

Q 2. The tire has four basic parts: beads, plies and belts, tread, and innerliner. Which of these parts are tested by each of the tests below?

a) Bead Break-Away
b) Plunger
c) Endurance

a) The Bead Break-Away Test measures bead strength and ability to stay round when pressure is applied to the tire's side. It also measures the ability of the innerliner to maintain its seal against the wheel's rim.

b) The Plunger Test measures the strength of the cords inside the tire (the innerliner and tread rubber are usually elastic enough to stretch, but not break in this test).

c) The Endurance Test measures the adhesion of the tread to the plies and thermal expansion problems which may pull parts of the tire apart.

ELASTICITY AND STRENGTH OF RUBBER BANDS

Goodyear is very concerned about the elasticity and strength of its products. Its tires must take blows, be bent, be stretched, and still give smooth, safe rides.

You are also concerned about elasticity and strength. Elasticity or strength is too low when your pants split, the rubber band snaps, or the house paint cracks.

Many things can affect the elasticity and strength of rubber bands. Age, length, thickness, tears along the edge, width, temperature, number of stretches, and twists could all affect the rubber band.

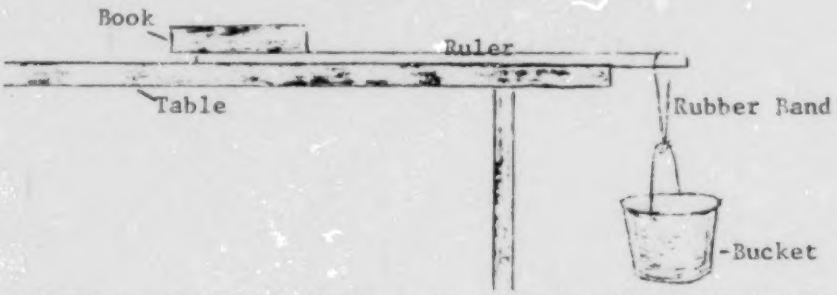


Figure: Apparatus for measuring the elasticity and strength of rubber bands.

To measure the elasticity of rubber bands, hang the band over the end of a ruler extended over the edge of a table. Loop one end of the band around the handle of a light plastic bucket, and slowly add mass to the bucket.

Test two rubber bands that are the same in all but one way. For instance, you could use a new wide and a new thin rubber band, a rubber band that has been stretched many times and an identical band that has not.

Carefully measure the amount of stretch after each addition of mass to the plastic bucket. Record and graph your results for both rubber bands.

STUDENT SELF TEST QUESTIONS

1) Did your rubber band stretch more, or less, with each addition of mass toward the end of the trial? How is this shown by the graph?

2) What would happen to the graph if two identical rubber bands were tested at the same time instead of one? Would the shape of the curve be the same?

3) Which part of the tire should be the most elastic? The tread, plies, or inner liner?

ELASTICITY AND STRENGTH OF RUBBER BANDS

Rubber Band #1
Description

_____

_____

Mass	Length

Rubber Band # 2
Description

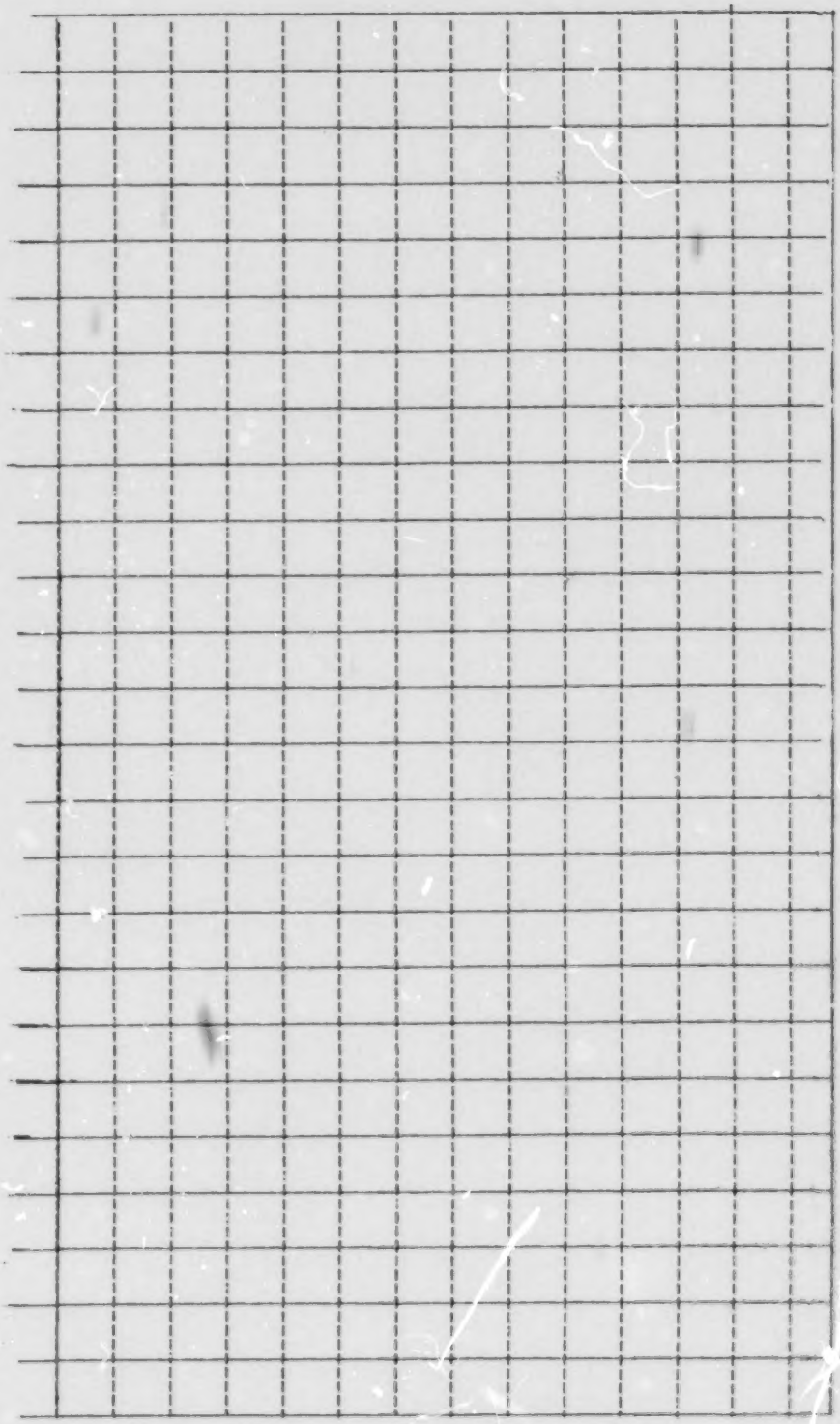
_____

_____

Mass	Length

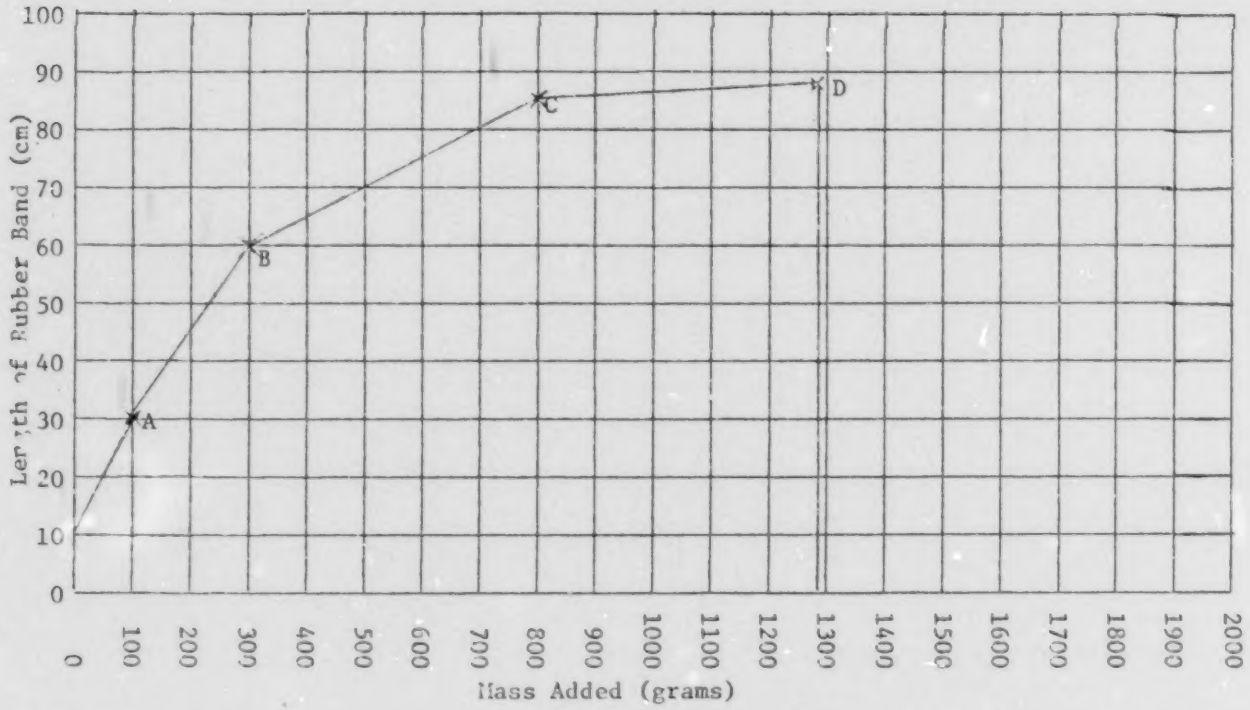
Graph

Length of rubber band units =



Mass added to rubber band units = _____

Optional Graphing Exercise



This graph shows the length of a rubber band supporting increasing amounts of mass.

1) How long was the rubber band when it supported no mass?_____

2) How long was the rubber band, and how much mass did it hold at point A?

   Length_____ Mass_____

3) What was the length and mass at point B and point C?

   B - Length_____Mass_____ C - Length_____Mass_____

4) How much would the rubber band's length <u>increase</u> when its mass was raised from 100 to 200 gms? _____ 300 to 400 gms? _____ 800 to 900 gms? _____

5) If 200 grams were added to the rubber band, would its length increase more at point A, point B, or point C? _____

6) What happened at point D? _____

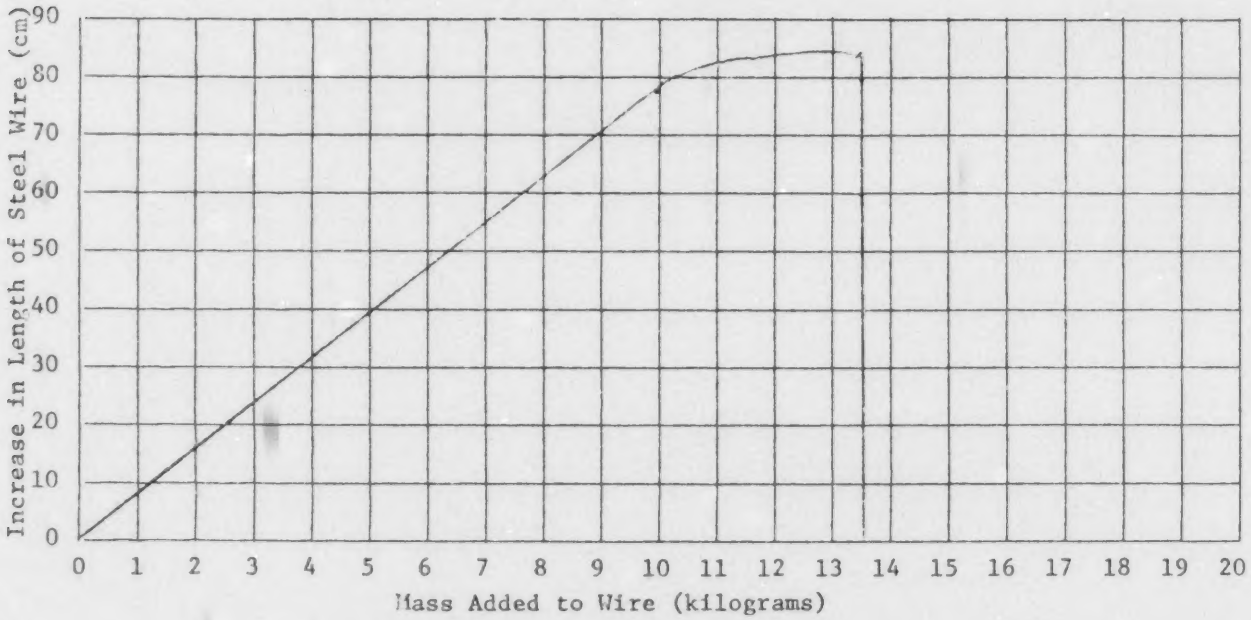
7) If two rubber bands, like the one in the graph, were hooked side by side to one mass container, predict their length for each of these masses:

   0 gms - Length = _____ 200 gms - Length = _____

   400 gms - Length = _____ 800 gms - Length = _____

   1400 gms - Length = _____ 2000 gms - Length = _____

8) On the graph above, draw the line you would predict for the elastic strength of the rubber bands described in question 7.



This graph shows the increase in length of a long, steel wire when mass is added.

9) How much did the wire increase in length when the mass it was carrying increased from 0 to 7 kilograms? _____ from 6 to 13 kilograms? _____

10) Did the length of the wire increase most rapidly when mass was first added, or just before it broke? _____

11) Two wires, like the one graphed above, were both hooked to the same mass.

a) How much mass would be required to break two wires? _____

b) How much would the two wires stretch before breaking? _____

c) What increase in length would be expected for two wires supporting these masses?

2 kilograms - length = _____ 4 kilograms - length = _____

12 kilograms - length = _____ 8 kilograms - length = _____

20 kilograms - length = _____ 16 kilograms - length = _____

12) On the diagram above, draw the line you would predict for two steel wires as described in question 11.

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Behavioral Objective Number	Topics and Concepts
16	Given the graph of elasticity for one rubber band, students should be able to select the curve expected for two overlapping rubber bands.
17	Given a graph of elasticity, students should be able to select an interpretation which best summarizes the relationship between length increases and increasing mass.
18	Given a graph of the thermal expansion of aluminum, students shall be able to determine the values of the coordinates for a particular point on the graph.

Teacher Suggestions

Test results in previous years have indicated that students have a very difficult time interpreting graphs. This experiment is designed to give more practice on this essential skill. The behavioral objectives are written at three levels:

1) Can the student determine the coordinates of one point on the graph?

2) Can the student interpret the graph well enough to provide a verbal description of the behavior of the material being measured?

3) Can the student apply the information on a graph to produce a realistic prediction of the behavior of materials in a new situation?

In the past, fewer than 50 percent of the students have been able to perform at levels two and three.

Presenting the Experiment: We would suggest having students work in pairs. Have each group stretch identical rubber bands the first time, then allow each team to test another rubber band (or bands) for a different variable. Some variables are suggested in the third paragraph of the student paper.

Masses in 100 gram quantities work well for this experiment. If you do not have enough sand, lead, or brass masses, use 100 ml of water as mass units. Several 100 ml graduate cylinders may be checked out from the project office for this purpose. We also have rulers available if needed.

Precautions: Explain to the students that the rubber bands should not be stretched by hand before starting or during the experiment. The bands are not totally elastic and will not return to their original shape. Therefore, hand stretching will provide a sudden increase in length which will not correspond to the increased mass on the band.

When the graphs begin to level off so that an increase of 100 grams of mass causes an increase of less than 1 cm in length, the breaking point of the band is being neared. We would suggest a limit of 1,500 grams per rubber band.

We strongly recommend that the teacher do this experiment, using student materials, before using it in the classroom.

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Suggestions for using student graphs: The graph on page D-2 should be duplicated for student use with this experiment. Transparency 1 in the back of the teacher's manual may be used to help students fill in their graphs and to practice interpreting various curves. Transparency 2 contains realistic data from two experiments and may be used as wished.

The optional graphing worksheets on pages D-3 and D-4 may also be duplicated and used if desired. Transparency 3 contains the graphs from these pages. The answers to these questions are found in the student self-test section.

All students should be able to work out the verbal questions in the optional graphing exercises. Slower students will have trouble with the graphing required for questions 5 and 8, but the effort toward interpreting and extrapolating these graphs will help toward developing essential graphing skills.

Answers - Student Self-Test Questions

Q 1) Did your rubber band stretch more, or less, with each addition of mass toward the end of the trial? How is this shown by the graph?

A The bands should stretch less toward the end of the trial. This is shown by the graph curving more toward the mass axis as the trial moves along.

Suggestions: Use the transparency of the student graph to show a curve which would show increases in length with additional mass so that students can practice interpreting the graphs.

Q 2) What would happen to the graph if two identical rubber bands were tested at the same time instead of one? Would the shape of the curve be the same?

A Students should point out that there are two possible answers to this question. If two overlapping rubber bands are tested, twice as much mass should be needed to make the same increase in length as is found with one rubber band. A picture similar to the one on the left will help make this point clear. If the rubber bands are stretched end to end, twice as much length increase should be shown for the same mass.

Have students draw curves that would be expected for both of these cases; then have them predict the curve for three rubber bands.

Q 3) Which part of the tire should be the most elastic? The tread, plies, or innerliners?

A The plies are the least elastic. In car tires, the innerliner is usually the most elastic. In truck tires, the tread is more elastic. This is because the truck tire is usually exposed to rougher surfaces and more stress than the passenger tire, and the tread must be more elastic to take the strain.

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Answers - Revised Optional Graph Exercise

1) How long was the rubber band when it carried no mass? 10 cm

2) How long was the rubber band, and how much mass did it hold at point A?

   Length 30 cm Mass 100 gm

3) What was the length and mass at point B and point C?

   B - Length 60 cm Mass 300 gm C - Length 85 cm Mass 800 gm

4) How much would the rubber band's length increase when its mass was raised from 100 to 200 gms? 20 cm 300 to 400 gms? 8 cm 800 to 900 gms? 1 cm

5) If 200 grams were added to the rubber band, would its length increase more at point A, point B, or point C? A

6) What happened at point D? The rubber band broke

Learning to read a graph's coordinates and (given coordinates) to plot a graph is a fairly simple skill. The ability to interpret and translate a graph into verbal descriptions is harder. The ability to take a non-linear graph and project its data to a new situation is more complicated. In dealing with questions seven and eight, students must realize that: 1) the increasing mass does not create a proportional increase in length in most real situations; 2) to determine the length of two or more rubber bands hooked in tandem, the mass must be divided to determine the amount supported by each rubber band; 3) when the mass supported by each band is determined, the length of all rubber bands can be read from the tables.

You may wish to challenge your better students to plot the graph of three rubber bands hooked in tandem.

7) If two rubber bands, like the one in the graph, were hooked side by side to one mass container, predict their length for each of these masses:

   0 gms - length = 10 cm 200 gms - length = 30 cm

   400 gms - length = 50 cm 800 gms - length = 68 cm

   1400 gms - length = 82 cm 2000 gms - length = 85 cm

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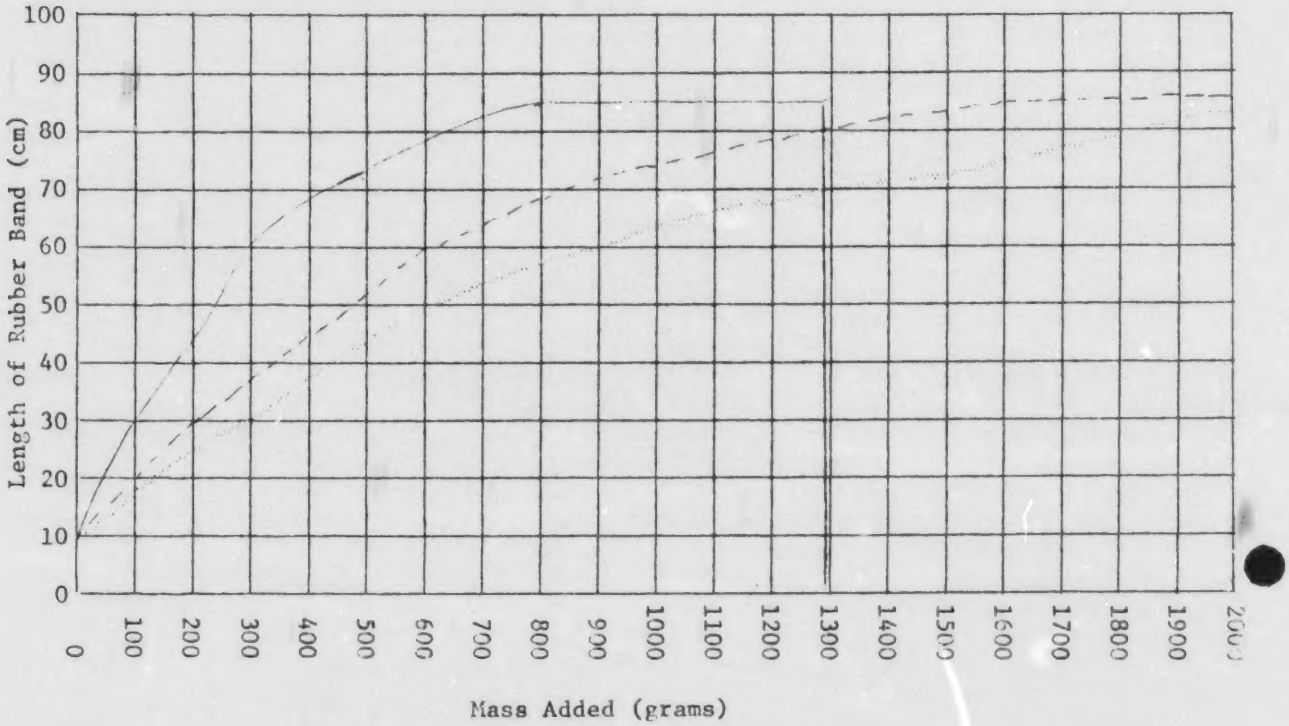
8) On the graph below, draw the line you would predict for the elastic strength of the rubber bands described in question 7.

——— 1 rubber band ····· 3 rubber bands (tandem)
·····2 rubber bands (tandem)



This chart shows the lengths of one, two, and three identical rubber bands supporting increasing amounts of mass.

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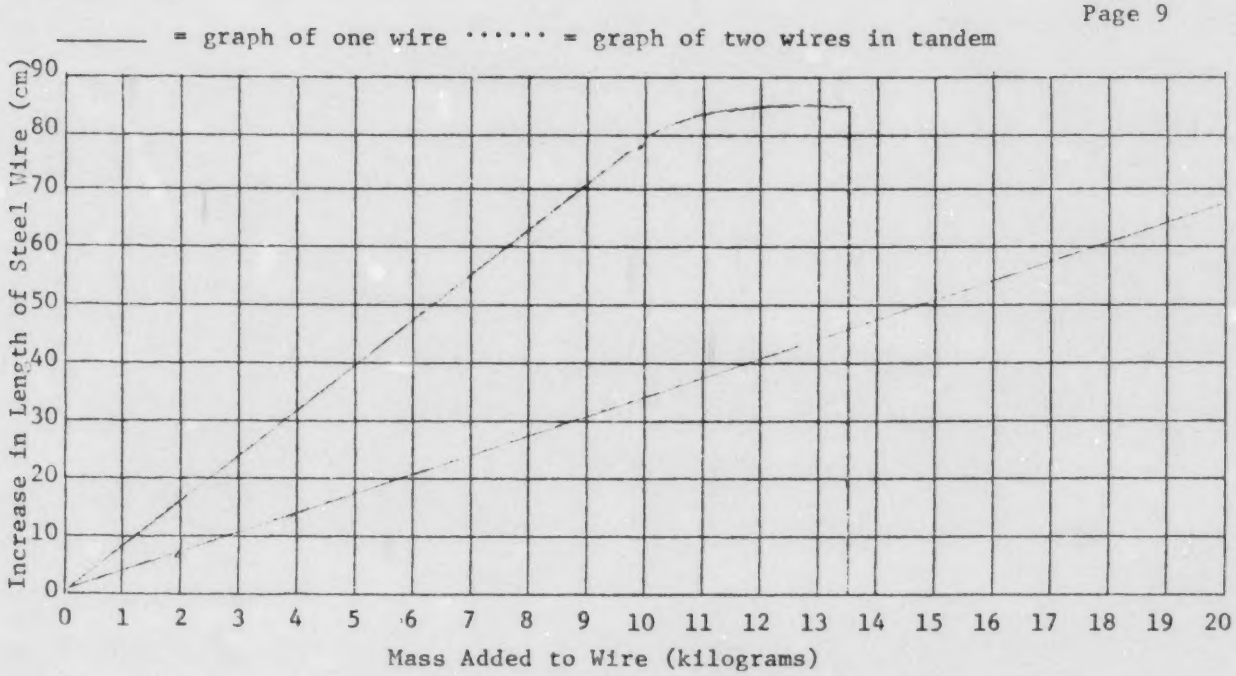
——— = graph of one wire ····· = graph of two wires in tandem
Increase in Length of Steel Wire (cm)
0
10
20
30
40
50
60
70
80
90
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Mass Added to Wire (kilograms)

This graph shows the increase in length of a long, steel wire when mass is added.

9) How much did the wire increase in length when the mass it was carrying increased from 0 to 7 kilograms? 55 cm from 6 to 13 kilograms? 36 cm

10) Did the length of the wire increase most rapidly when mass was first added, or just before it broke? When mass was first added.

11) Two wires, like the one graphed above, were both hooked to the same mass.

a) How much mass would be required to break two wires? 27 kilograms

b) How much would the two wires stretch before breaking? 84 cm

c) What increase in length would be expected for two wires supporting these masses?

2 kilograms - length = 8 cm 4 kilograms - length = 15 cm

12 kilograms - length = 48 cm 8 kilograms - length = 31 cm

20 kilograms - length = 78 cm 16 kilograms - length = 62 cm

12) On the diagram above, draw the line you would predict for two steel wires as described in question 11.

Note: The graph above is a reasonably accurate display of the increase expected for a 40-meter steel wire with a radius of 0.75 mm.

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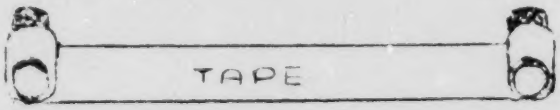
OPTIONAL EXPERIMENT - ADHESION OF TAPE

One of the most important physical properties of Goodyear's materials is adhesion. Rubber must adhere to cord in the plies. Wire and rubber must show strong adhesion in the beads, and the tread rubber must have very strong adhesion to the tire carcass. If any of these materials do not show strong adhesive properties, the tire will fly apart.

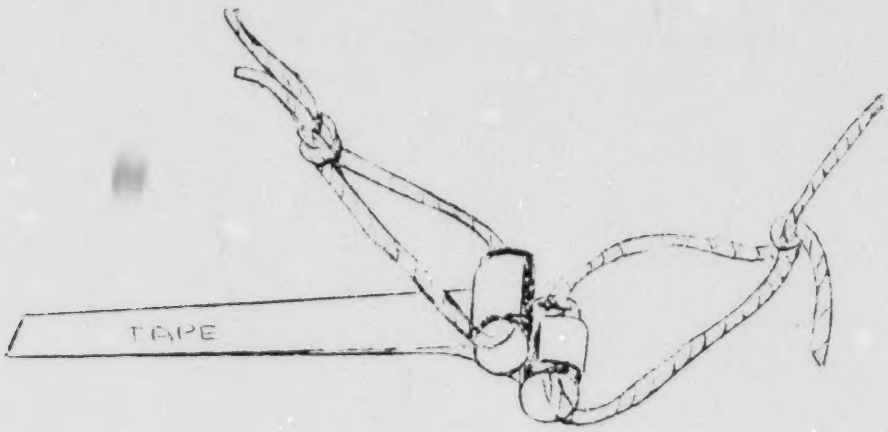
Tape is a common material which adheres to most surfaces. Many things may influence the adhesion, so testing it can be a challenge. Some of the factors which you might wish to compare could include width, age, type, or brand of tape; how tightly and smoothly the pieces were pressed together; or how many times the pieces were pulled apart.

This experiment will test the adhesive properties of tape. The method we will use is similar to one that Goodyear uses for all of its tests. Everyone in the class should test the same kind of tape under the same conditions the first time, then each team should select a problem and test it once. For instance, the entire class might test ½ inch wide masking tape, then one team might test ½ inch wide Scotch tape or strapping tape under the same conditions.

To measure adhesion, take a piece of tape about 30 cm long. Roll each end around a short piece of plastic tubing.

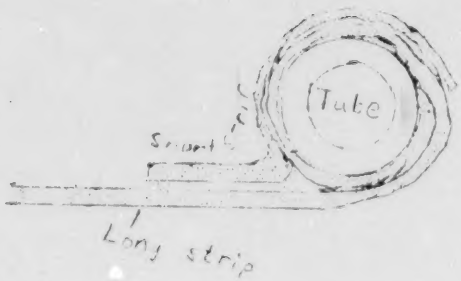


Carefully fold the sticky sides of the tape together. Try to avoid wrinkling the tape, since this will affect your test. Insert a 40 cm length of string through each tube, and tie a loop in the string.

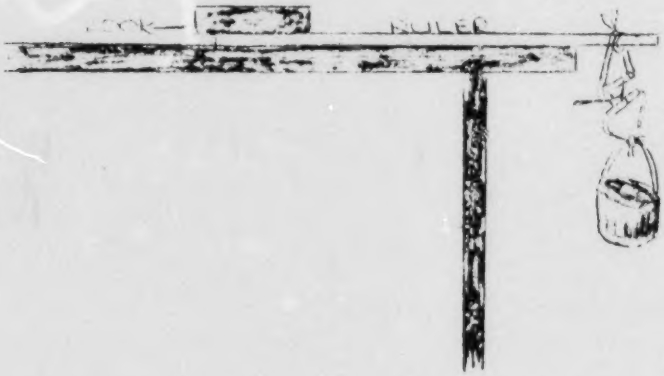


The Eisenhower Weld

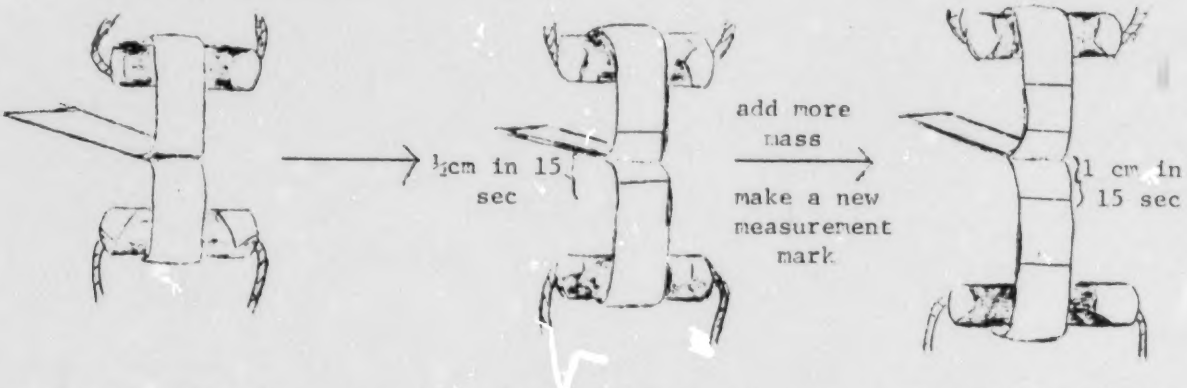
Before hanging weight on the tape, stick a short piece of tape face down against the adhesive side of the long strip. Wrap the short tape up and around the tube. This procedure allows the tubes to withstand strong force without rolling.



Double-loop one of the strings around the end of a ruler, and tie the other string to the handle of a plastic bucket. Place the ruler on the edge of a table, and hold it down with a book.



Pull the tape apart about 2 cm with your hands. Then carefully make a distinct pen or pencil mark across the exposed part of the tape at the seam. Add mass to the bucket, and wait 15 seconds. See if the tape has started to pull apart. Keep adding mass until the tape begins to separate. Measure how far the tape pulls apart in exactly 15 seconds. Make another mark across the seam and add or subtract mass. Use different masses until separations from 0.5 to 2.5 cm have been achieved in 15 seconds. Hold the loose end of the tape level with the ground during these trials.



Use your team's data to construct a graph showing tape separation in 15 seconds for different masses. From your graph, select the mass which would probably cause a separation of 1 cm in 15 seconds. Combine your results with those of your classmates to make a class histogram. Record your results on the papers supplied by your teacher.

Student Self-Test Questions

1) Does the shape of your class histogram indicate that all of your classmates did the experiment carefully? How can you tell?

2) If you were to assign one measurement to the tape's adhesive strength, what one would you use? Why?

3) How much mass should be required to separate a piece of tape just like yours, but twice as wide?

ADHESION OF TAPE

Tape Description

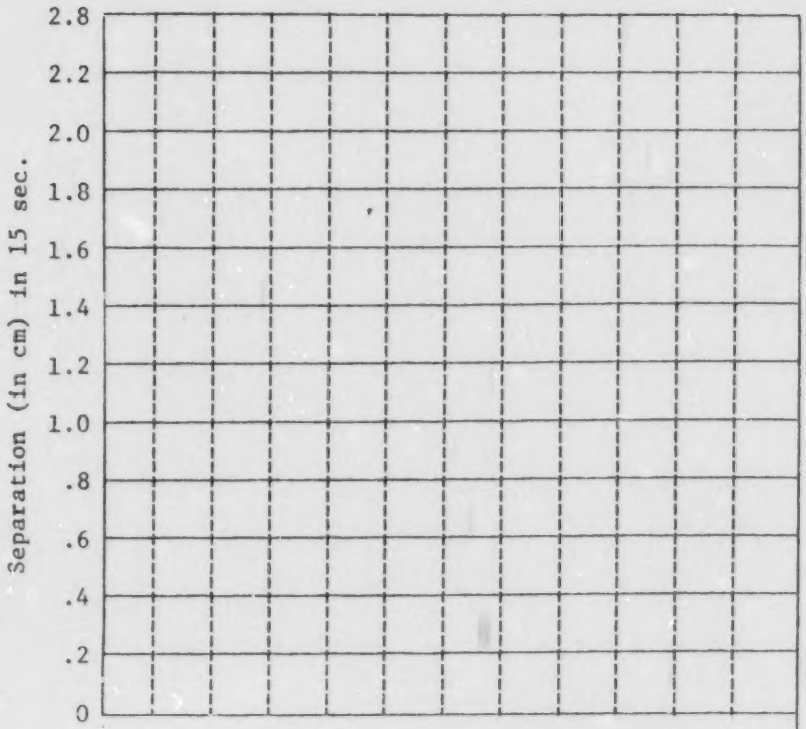
_____

_____

Distance separated 15 sec	Total Mass

Mass required to separate 1 cm in 15 sec =

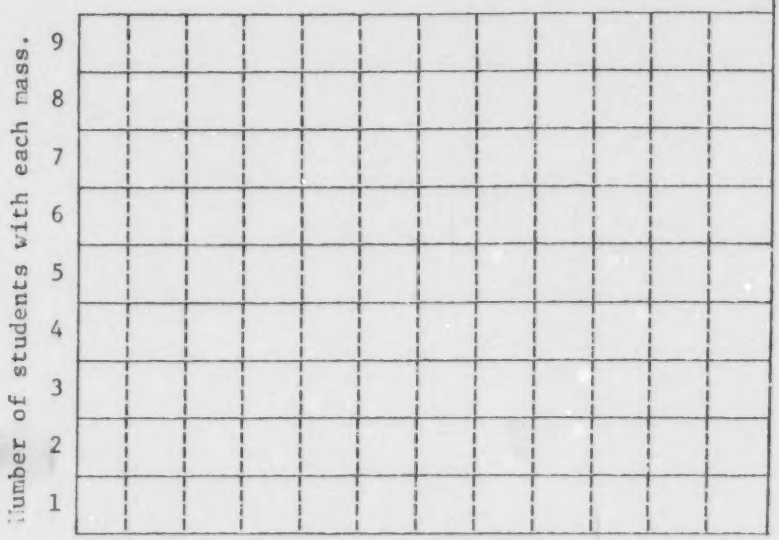
Adhesion of _____ tape



Mass used to achieve separation in 15 sec.
Units of mass = _____

Class Results

Mass for 1 cm separation in 15 sec



Mass needed for 1 cm separation/15 second units = _____.

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Behavioral Objective Numbers	Topics and Concepts
9	Students should be able to identify "adhesion" with the role it plays in tire construction.
19	Given a histogram displaying many measurements of the same object, students should be able to select the "best" measurement.
20	Students should be able to match the sketch of the test for adhesion with a description of the test.

Teacher Suggestions

This experiment has an initial, basic goal of reinforcing the student's knowledge of histograms while studying adhesion and some of the variables which affect it. It can easily be broadened into a study of different types of tape, and the use of science in protecting the consumer, if the teacher wishes to spend another day on the experiment.

To present this experiment, you should have 10 kilograms of masses available in 50 and 100 gram quantities, or graduate cylinders and water. If students follow directions for taping the plastic tubing so that it will not roll, water will not be spilled except by careless handling.

You should definitely try this experiment once before presenting it to the class.

If you have torn 30 cm strips of tape for your class, have cut strips of string, and have previously reviewed the procedure, your class can complete this experiment in one hour. The concept is simple, but the materials and methods are unusual. Transparencies 4 and 5 may be used to help your class graph their results.

Answers - Student Self-Test Questions

Q 1) Does the shape of your class histogram indicate that all of your classmates did the experiment carefully? How can you tell?

A Use the transparency of the histogram paper to discuss this question. Point out that, when everyone is testing the same thing, a fairly tight bell curve is expected. Careless procedure by a few students will lead to answers far from the center of the curve.

Q 2) If you were to assign one measurement to the tape's adhesive strength, what one would you use? Why?

A The best answer is the one which most students have reached (by measuring) if it is approximately in the center of all responses. If the answers are spread evenly over a wide range, the best answer is an average of all numbers; however, this method is not as reliable as the former, since there is no consistency in student responses.

Q 3) How much mass should be required to separate a piece of tape just like yours, but twice as wide?

A Twice as much mass should be required.

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ECONOMICS OF GOODYEAR

Papers B and C presented the techniques Goodyear uses to make its tires. This paper shows how the corporation uses the money it receives from the products it sells.

The Goodyear Corporation has plants in many countries, and it produces and sells under many economic systems. Each economic system, of course, is determined by the political system of the country in which it is located. Most systems have a mixture of statism and capitalism.

The economic system of statism allows the government (or state) to set a company's policies. When government can require a company to meet safety, pollution, or advertising regulations, or when governmental actions control competition, statism is shown.

The economic system of capitalism allows trade without government restrictions. Under capitalism, companies set their own prices, wages, quality control standards, and other policies at levels which are designed to make a profit.

In the United States, we have an economy which is a mixture of both capitalism and statism. Companies still make most decisions themselves, but many choices are restricted by the government. The ability of each company to meet government requirements, and still to be successful, depends on its ability to be a profitable trader.

Individual Trade: A good trade is one that helps both traders. For instance, someone with 40 cents could spend it on many things. If he chooses to buy a hamburger, he decides that it will help him more than anything else which could be purchased with 40 cents. The person selling hamburgers chooses to use his time and knowledge selling hamburgers, even though many other jobs are possible. When each trader profits, as a result of the trade, then it is a good trade.

It is a bad trade if either trader fails to profit. The buyer does not profit if the hamburger tastes bad, or is too small to be filling. He spent 40 cents poorly. The seller would not profit if it cost him 41 cents to make the hamburger and he lost a penny on each sale. Thus, the capitalistic system works best when every person can trade his skills, time, and money for the things which will provide profit both to himself and other traders.

Corporate Trade: When a group of individuals combine their trading abilities to form a unit, this is known as a company, or corporation. The corporate trading unit acts much like an individual in a trade. It purchases, sells, and tries to profit while giving profit with each sale.

Most corporations are owned by stockholders who trade (invest) their money for ownership of a share of stock. Stockholders control their investment by choosing the corporation's board of directors. The board of directors makes the long-range decisions that determine the future of the corporation and select the company's high-level officers. If the stockholders invest their money in a good corporation, and if they select good directors and officers to operate it, the corporation will profit from its trades and the value of each share of stock will rise. If they invest in a corporation and in men who trade poorly, the value of each share of stock will decrease.

Corporations (and individuals) have good years and bad ones. People who trade their money for stocks look at both past and present growth to select corporations which are trading well or which can be expected to trade well in the future.

Goodyear's Trades

From 1943 through 1972, the Goodyear Corporation stock increased in value by 1,685 percent. This means that an investment of $100 in 1943 was worth $1,785 in 1972. The corporation has plants manufacturing tires and other products throughout the world. It sells products ranging from radar and atomic fuels to natural rubber and floor tiles. Over the years, it has traded well.

During 1973, which was a typical year, the corporation traded its products for about 4.5 billion dollars. Since 4.5 billion dollars is a lot of money to think about, we'll simplify the example and talk about just one of those 4.5 billion sales dollars, with the understanding that every dollar was spent the same way.

Employees: Goodyear traded 34 cents from each sales dollar to employees in exchange for their knowledge, ability, and effort. Employees manufactured products, sold products, designed new products, and decided which products would be produced.

Materials and Energy: Goodyear traded 54 cents from each sales dollar to companies who supplied the corporation with materials used to make its products. These materials include rubber, fabric, wire, and fuels, such as electricity, natural gas, and oil.

Government: Goodyear traded 5 cents from each sales dollar in taxes to governmental units. The government provided the corporation with many services, including judicial, educational, monetary systems, and the protection of its property by police departments and the armed forces.

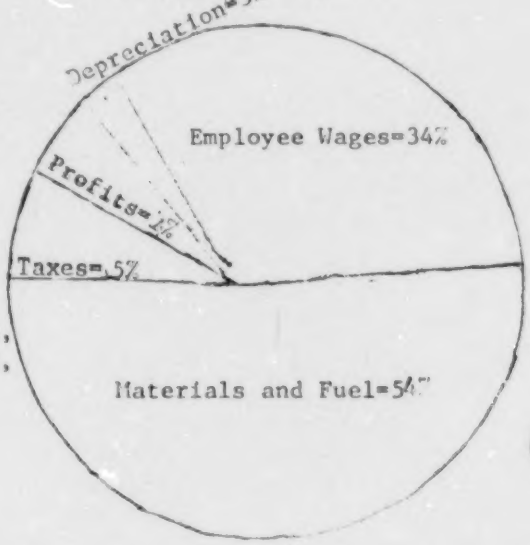

Figure 1. Distribution of Goodyear's 1973 Corporate Income

Depreciation: Goodyear traded 3 cents from each sales dollar to manufacturers for new machinery and equipment to replace that which wore out during the year.

Profits: After vendors were paid 54 cents, employees were paid 34 cents, governments were paid 5 cents, and equipment manufacturers were paid 3 cents (a total of 96 cents), 4 cents was left for the stockholders. This 4 cents from each 100 cents worth of sales was the corporation's profit. In 1973 Goodyear stockholders reinvested 2.5 of their 4 cents for building new plants and for buying new equipment. The remaining 1.5 cents was paid as dividends (profit) to the stockholders. In addition, because of reinvestment of 1972 profits during 1973 the value of each share of stock grew.

If you owned one of the 71 million shares of Goodyear stock in 1973 your real dollar "economics" would have looked like this:

> January, 1973 one share of stock had a book value of $21.80
> December, 197 , one share of stock had a book value of $23.46, and you would have received 96 cents in dividends (profits). Your investment would have grown by over 12 percent.

ECONOMICS IN MORE DEPTH

Human Ability: To make products which sell at a profit, corporations must obtain the knowledge and effort of the best possible people. To obtain competent employees, the company must offer satisfactory wages and working conditions, since employees will choose to work wherever they can make the most profitable trade for their talents.

To attract good employees to the Topeka facility, Goodyear offers the following:

1) Competitive Wages: The average production employee earns $5.15 per hour. Working 40 hours per week, and 50 weeks per year at this rate provides a wage of about $12,000. Overtime work can push the wages higher. These wages are equal to, or better than, wages for similar work in this area.

2) Competitive Benefits: More than 20 kinds of benefits are offered in addition to wages. These benefits range from paid insurances and vacations to discounts on Goodyear products. The average value of these benefits to each employee is $4,000.

3) Opportunity for Advancement: Employees in all Goodyear jobs can apply to change jobs. Nearly all of the Corporation's best jobs go only to people who have excelled at other work for Goodyear.

4) Competitive Working Conditions: Safety, lighting, noise levels, temperatures, break periods, and other working conditions are adjusted to attract and hold competent employees. A system of rewards for efficiency and safety suggestions helps identify areas needing improvement in working conditions.

Materials and Fuel: To make tires requires more than just human effort. Raw materials (rubber, sulfur, etc.) and energy from oil, gas, and electricity are required. Fuel to operate machines has become very important for all industries. Today's American has the equivalent of hundreds of slaves worth of energy at his command and without that energy, most industries could not produce. As the availability of fuel decreases, and its cost increases, corporations have but two choices: pay more, or go without and shut down.

If fuel is available to the highest bidder, then Goodyear will bid against Firestone, chemical manufacturers, and all other users of fuel. The most efficient companies making the most in-demand and profitable products will be able to buy energy and sell their products. Other companies will operate at a loss or be unable to buy fuel and will halt operation.

If fuel is rationed, Goodyear has no choice but to reduce production. It will shift fuel to its most efficient and essential plants and reduce the production in other plants.

In either case, as the cost of fuel increases, the cost of products must go up if Goodyear is to continue to profit. If the products are needed, trades will be made; if not, then goods will not be sold and profits will drop.

Capital: Surplus money that can be used to purchase new buildings and equipment is called capital. Money used to pay labor and purchase supplies is not capital. Men, materials, and energy could not produce tires unless capital was available to build the plant. Corporations obtain capital to build new plants in three basic ways: selling stocks, obtaining loans, and producing profits. Stocks are sold by the

company when it wishes to grow. They are purchased by investors who trust the corporation's ability to grow and produce a profit. If the company grows well, the stocks grow in value and can be sold at much more than the original cost. If the corporation does not prosper, the stocks may become worthless. Goodyear sells around 200 thousand new stocks every year and investors may bid for these, or may purchase stock from other traders who own shares.

Loans may be obtained by mortgaging equipment and buildings which are already owned. Thus, the value of past investments may be used to obtain capital for new investments.

Profits from existing processes and products provide the third major source of capital to a company. Profits not only are used to pay dividends to stockholders but are also used as capital to finance new enterprises. Without profits, no company can continue to exist in a capitalistic system.

SUMMARY

Businesses are like people. They must continue to improve or they stagnate and die. Capital is needed if a corporation is to build new plants which will produce new products to replace products which no longer can be traded.

If Goodyear still produced the thin, easily punctured, rough-riding, tubed tires of the 1940's, no one would purchase its tires. New technology, competent men, and capital produced from profits, loans, and stock sales allowed the development of first rayon, then nylon, then polyester, then belted, and finally, steel-belted radial tires. The newer tires cost more to produce, cost more to buy, but give better service than the older tires.

In summary, science and technology can invent many, many products. Our economic system influences the quantity and quality of products actually available for our use.

Our supplies of fuels and raw materials are used to produce the many products. As energy and raw material supplies change, science, technology, industry, and our total economic system will face a new and large challenge if our standard of living is to remain high.

Student Self-Test Series

1) Which two of these businesses can operate in the most capitalistic way? Explain your answer.

   a) McDonald's
   b) Rees Fruit Farm
   c) Topeka Bus System
   d) Kansas Power and Light
   e) The neighborhood lawn-mowing service

2) What factors have led to increased statism (governmental control of business) in the United States?

3) Why must businesses make profits in order to survive in a capitalistic system?

4) When fuel prices increase, suggest two actions which businesses can take.

5) Goodyear spends 34 percent of its income on labor and 54 percent on materials, fuels, and so on. What proportion of Kansas Power and Light Company's budget do you think goes toward these two areas?

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Behavioral Objective Numbers	Topics and Concepts
21	Students shall be able to select the best summary of the degree of governmental control of business in the United States.
22	Students shall be able to select the most realistic distribution of Goodyear's income for raw material purchases, labor costs, and profit.
23	Students shall be able to apply the definition of "capital" to select the best use for it in business.
24	Given four possible results of adding pollution control equipment to a manufacturing plant, students shall be able to select the most realistic outcome.

Teacher Suggestions

This paper was prepared to provide a brief introduction to the economic system of today's United States. Objectives 21-23 can be met through a discussion of the Student Self-Test questions. Objective 24 will be developed primarily in the paper "Pollution Control at Goodyear."

The material below provides background for potential discussions of some aspects of economics brought up in the student paper. The topics (statism vs. capitalism, corporate trade, Goodyear's trade, human ability, and capital) are presented in the sequence used in the student paper.

Statism vs. Capitalism: Any governmental action controlling production or distribution of goods is, by definition, a statist action.

Any governmental action protecting the ownership of land and other property by individuals and encouraging the production, distribution, and exchange of goods through free enterprise is, by definition, a capitalistic action.

In short, in the United States, we have a maze of statist laws controlling how goods are produced (occupational health and safety laws, for instance); how they are distributed (import - export laws, interstate transport laws, etc.); and how they are sold (Federal Trade Commission regulations of advertising, price control regulations, etc.).

Most of these laws were designed to curb abuses of the capitalistic system of private enterprise and competition while protecting employees and consumers from abuse. In other words, health and safety laws were written to protect humans from dangerous working conditions. These laws, in protecting the worker, restrict the freedom of the employer.

In practice, because laws are written and administered by men, government has had difficulty walking the tight rope between controlling abuse and becoming the abuser. This conflict is shown by the present fuel problems in the United States. Much of the sudden shortage can be traced to government policies which discouraged explora-

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tion, lowered investment in refineries, provided poor natural gas pricing structures, and so on. All of these regulations were intended to help most Americans, but the elimination of a competitive market turned out to be a mistake.

Corporate Trade: Under most United States laws, corporations are treated as an individual. Thus, a corporation may be sued, taxed, and discussed as though it were one person.

Goodyear's Trade: The data used in the students' paper was obtained from Goodyear's annual report of 1973. Past years had very similar figures, and data for 1974 was not available when this paper was published.

Some students may question how $100 can increase 1,685% to $1,785. This is obtained by adding the stock's original value ($100) to its growth value ($1,685). "Book value" of a stock is the value of a company's holdings minus its liabilities and divided by the number of stocks owned. In Goodyear's case, a stock's book value of $23.46 is determined by dividing the company's value (1.5 billion dollars) by the 71 million shares of stock now owned by stockholders. In theory, if the company disbanded, the book value is what each share of stock would be worth. The value of the stock in the stock market is, of course, determined by what other people think of the company's potential. In 1974 Goodyear's stock market varied, with a high of around $18.00.

Some students may ask how Goodyear's stock could increase in value by 1,600 percent and still be worth only $18.00 dollars. Companies can affect stock values by dividing (or splitting) their stocks as their worth rises. In other words, when Goodyear's stock rises in book value to around 40 dollars, the corporation's board of directors announces a two-for-one split. This doubles the number of shares and halves the value of each share. This also allows the small investor to continue to purchase shares without a major investment.

Human Ability: Goodyear statistics indicate that, since 1945, the average value of employee benefits added to regular wages has grown from $61 to $4,000 in the Topeka facility. Some benefits, such as Goodyear's share of Social Security payments, are quite costly. Others, such as the bookkeeping cost of allowing payroll deductions, are relatively inexpensive. The benefits provided include these:

1. Paid vacations from two to six weeks
2. Company's share of Social Security payments
3. Ten annual holidays
4. Pension plan
5. Medical insurance (Covers physician, hospital, and dental bills.)
6. Non-contributory major medical insurance
7. One dollar deductible prescribed drug plan
8. Life insurance
9. Jury duty pay
10. Funeral leave pay--three days
11. Military reserve annual training make-up pay
12. Employee suggestion system payments
13. Stock investment plan
14. Christmas party
15. Diamond emblem and $100 or wristwatch after 25 years
16. Employees Activities Committee
17. Educational tuition assistance
18. Scholarships for children
19. Selected discounts at service stores
20. Payroll deduction for U. S. Savings Bonds
21. Payroll deduction for United Fund
22. Flowers for relatives' funerals

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Since production workers work varying hours, at variable rates, and with varying amounts of overtime, it is hard to pinpoint an "average" worker's income. A rough "average" income of $12,000 per year can be determined by dividing Topeka-Goodyear's annual payroll of 49 million dollars by the 3,900 employees on the payroll. Changing levels of production, due to fuel availability problems, will, of course, affect this payroll.

In addition to providing monetary benefits and wages, the labor contract for production employees also provides a seniority system to control awarding of overtime work and many other topics. An impartial court to handle grievances against the company or employee is also part of the negotiated agreement. Many of the cases brought to the court are quite interesting to non-Goodyear personnel. Summaries of two cases are included below.

In grievance No. 5000-84, a warehouseman protested discharge.

The employee was discharged May 15 after a warehouse foreman found the grievant's truck out of his work area and the grievant away from his truck. In questioning the grievant when he returned to his truck from a lunch room, the foreman said that the grievant jumped from his truck and challenged the foreman to put him back on it. The foreman instructed the grievant to report to an office to discuss the incident but the grievant refused. The foreman contacted the union steward who brought the grievant to the office where the foreman suspended him for two days, pending possible discharge, for misconduct, insubordination and refusing to follow directions.

The company noted that the grievant was suspended for two days in 1971 for deliberately littering the warehouse floor, he was suspended for three days in 1972 for misuse of company equipment and he was suspended again in 1972 for displaying a disruptive sign on his power truck. In the last suspension, an umpire held that the grievant was entitled to "another chance to demonstrate that he can adjust to the plant community and is capable of cooperating with the reasonable efforts of his supervisors to maintain an efficient warehouse operation and proper compliance with the rules."

The union pointed out that since the grievant's last suspension, he has had a clean record, and maintained that the foreman was harassing the grievant about why he and his truck were not in the proper work area.

The umpire held that the critical incident was the grievant jumping off his truck and challenging the foreman to put him back on it. This act must be considered insubordination, he wrote. "The umpire emphasizes the point that it was the grievant who precipitated all of the subsequent action and reaction that occurred," Kindig said. Referring to the grievant's last suspension, Kindig said the grievant "was reinstated at that time, was given an opportunity to demonstrate that he could adjust to the plant community, and simply blew that chance." He denied the grievance.

Grievance No. 1501-152 protested the company removing pull chains from 3-ton hoists on seven E machines, and asked for back-pay for the time they were removed.

The chains, which controlled movement of the hoist on the trolley, were removed as an efficiency measure and resulted in tire builders having to manually move and control the hoist on the trolley.

The union contended that extreme effort is required to move even an empty hoist and that without the chains there is no way to stop it once it is moving. It cited a

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federal safety regulation that calls for a brake or mechanical means on a hoist to control bridge travel.

The company contended that builders, exercising normal caution, can use the hoist safely without the chain. Also, in connection with the back-pay request, it said it has the right to change operations and take advantage of resulting efficiencies.

The umpire sustained the grievance as to the re-installation of the chains, noting that the chains provide a form of brake and/or non-coasting device and that removing them was contrary to making reasonable provisions for the safety and health of employees. The umpire denied back-pay.

Capital: When government regulates profits (as they do with utilities), limits prices, or taxes profits heavily, business has trouble obtaining capital to produce new products or to expand to new markets.

As the availability of capital decreases, the options available to consumers also decrease. Businesses will not be as able to try new products, build new plants, or replace faltering equipment as readily. In addition, some businesses will fail. Presently, their products are replaced by new products from other companies. If capital becomes too tight, the range of consumer choices will just decrease with each business failure.

In addition, as the U. S. population growth rate slows, it will make the traditional growth rate of successful businesses dependent on non-population factors, such as new technology, changing material and fuel markets, and so on. Economists are not sure of how this problem will affect our future economy. One thing is certain, however: our economy's ability to make the transition from cheap energy, plentiful resources, and growing markets to the future as indicated by present trends will depend largely on the availability of capital and the freedom to use it. Government and business policies determined by the students we are teaching will play a large role in this transition--whatever its outcome.

Answers - Student Self-Test Questions

Q 1) Which two of these businesses can operate in the most capitalistic way? Explain your answer.

a) McDonald's
b) Rees Fruit Farms
c) Topeka Bus System
d) Kansas Power and Light
e) The neighborhood lawn-mowing service

A b) Rees Fruit Farms and e) the neighborhood lawn-mowing service operate enterprises which are the most free of governmental control. The owners of Rees must comply with various laws governing pesticide usage, zoning regulations, advertising practices, taxes, and so on. The neighborhood lawn mower is nearly free of governmental restrictions.

McDonald's has many more restrictions to comply with than do the first two businesses. Minimum wage laws, price controls, health inspection laws, interstate transportation laws, meat inspection, labeling laws, and many others will affect the products sold and the prices charged.

Kansas Power and Light faces hundreds of governmental regulations ranging from control of electrical supplies and control of competitors to the allowable level of profit.

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The Topeka Bus System is, of course, owned and operated by the government.

NOTE: The thrust of this question is to point out that most businesses have varying degrees of governmental control over the wages they pay, prices they charge, and products they produce. The United States has an economy which is a mixture of free enterprise and free choice (capitalism) and governmental control of business (statism).

Q 2) What factors have led to increased statism (governmental control of business) in the United States?

A 1) Political efforts to win votes and keep a "stable" economy have contributed to laws governing tariffs, transportation rates, costs of fuels, prices of goods, minimum wages, and so on.

2) Political activities of labor unions and other citizen's groups have urged laws governing health and safety regulations in nearly all businesses.

3) Serious mistakes and fraud have brought public pressure for laws governing the safety of drugs, additives in food, toy safety, insurance company practices, banking, stock sale practices, and so on.

4) Crowding has increased pollution concentrations, which has increased demands for laws restricting the freedom of business (and individuals) to release pollutants.

NOTE: In short, a whole host of abuses, desires to improve the system, increasing urbanization, and so on, have led to laws creating an economy which is an intimate mix of statism and capitalism. Since laws are rarely abolished, the trend has been toward increasing governmental control of business since this country was founded in 1776.

Q 3) Why must businesses make profits in order to survive in a capitalistic system?

A Companies which pay their bills, but make no profit, will be unable to modernize and take advantage of new technological discoveries. Only profits can attract stockholders and produce capital needed to discover and produce new products. Since competitors continually strive to produce products which sell better, the business which does not improve will soon disappear. It is this driving force which has produced better and better tires, more and more food, new clothing fabrics, televisions, and so on. One thing has, in the past, stopped the development of better goods--lack of economic necessity. This occurs when a conspiracy between companies controls the market or when the government controls the companies and market.

Q 4) When fuel prices increase, suggest two actions which businesses can take.

A Possible business actions can be grouped into these three broad categories:

a) Do without fuel, trim production, reduce heating and lighting, reduce profits and pay the bills without creating capital for new investments.

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b) Use capital to purchase machines which are more efficient, burn cheaper fuels, or make new products which require less fuel to produce. For example, Goodyear could switch from making tires for large cars to tires for bicycles. Bicycle tires require less fuel energy and more human energy to produce and to use.

c) Raise prices so that capital for future investment is still made, production is not curtailed, and the bills are paid. This is most successful for products in an inelastic market (such as food or fuel) where the product is purchased no matter what it costs. In an elastic market (such as boats and carpeting) higher prices will result in fewer sales and less required production.

Q 5) Goodyear spends 34 percent of its income on labor and 54 percent on materials, fuels, and so on. What proportion of Kansas Power and Light Company's budget do you think goes toward these two areas?

A Kansas Power and Light spends a much smaller proportion of its budget on labor costs than does Goodyear. Although its annual report is figured on a different set of divisions, it appears that Kansas Power and Light has labor expenses of about 12 percent of its income, taxes of nearly 28 percent, and material, fuel, and depreciation costs of over 50 percent. Kansas Power and Light is an industry which requires tremendous amounts of equipment and moderate levels of human employment. Have students suggest other companies which spend high or low proportions of their income on employment.

NOISE POLLUTION

The word "noise" is a combination of two Latin words meaning injury and sickness. Noise is usually defined as unwanted sound. Thus, one person's music may be another person's noise. However, if the sound is loud enough and lasts long enough, it will damage the human body, no matter what it is called.

To understand noise pollution, two concepts must be understood:

Decible is a unit of measurement for the loudness of sound. An increase of 10 decibles means that the sound level has doubled. Thus, a 40-decible sound is two times louder than a 30-decible sound. A 50-decible sound is 2 X 2, or four times louder than a 30-decible sound, and a 90-decible sound is 2 X 2 X 2 X 2 X 2 X 2 = 64 times louder than a 30-decible sound.

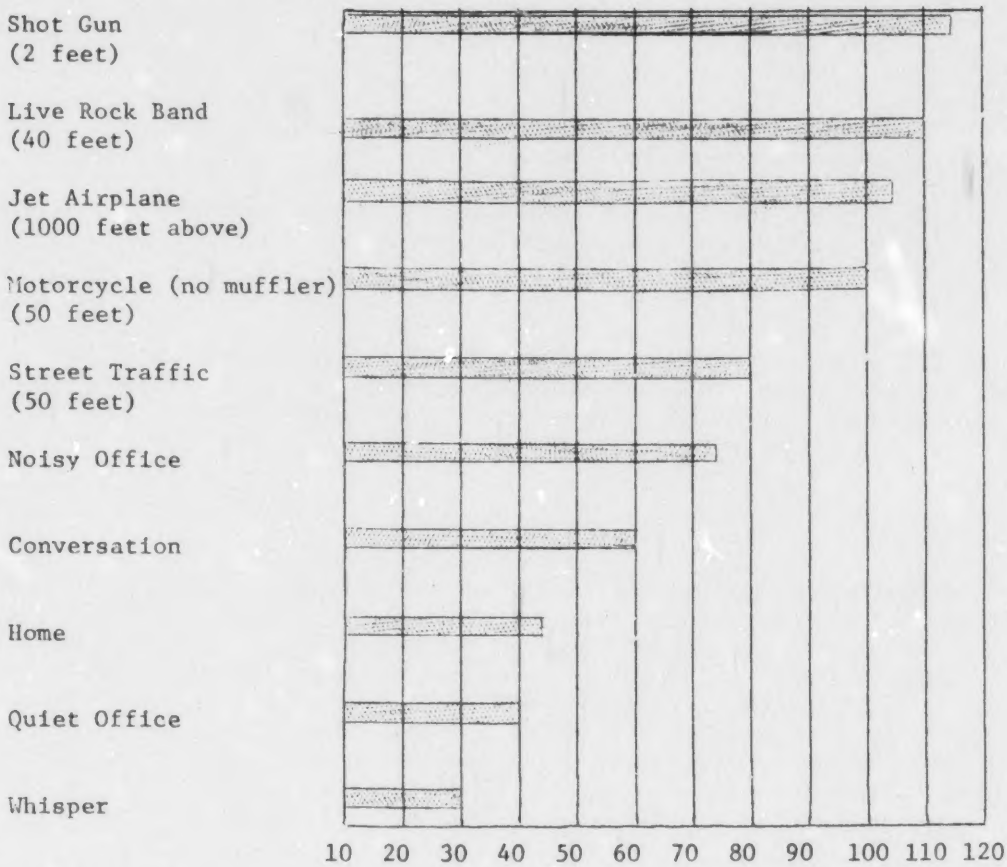


Chart 1. Comparison of decibles of sound received at common distances from the source.

Damage depends on time and volume. Evidence shows that, after receiving a 100-decible noise for two hours, the ability to hear is reduced but returns after rest. If the 100-decible noise is suffered eight hours per day, five days per week, hearing

damage begins to appear within months. Industrial data shows that slightly more than 90 decibles experienced eight hours per day, five days per week, causes measurable hearing loss after a few years. Data also show that different people react to the noise at different rates, and that some hearing loss is normal as humans age. It is clear that, except for very loud sounds, hearing damage from noise is very gradual and depends on the sound's loudness and length.

Hours of Daily Exposure	Decible Level
8	90
6	92.5
4	95
3	97.5
2	100
1	105
1/2	110
1/4	115

The chart to the left indicates the levels of noise permitted by most industrial noise regulations.

Chart 2. Hearing damage may be suffered if the decible level remains high for longer than the indicated time per day.

In addition to causing hearing loss, loud sounds also help cause headaches, high blood pressure, and other health problems. Noise causes particular harm when it occurs while a person is trying to rest. Loud noises from busy airports or highways may be particularly damaging.

An illustration of the need for quiet may be found in an ancient Chinese punishment for the worst of criminals. The sentence was death by noise. Flutes, drums, chimes, and gongs were played loudly and without let-up until the criminal dropped dead--which seldom required more than a few days. This torture was said to cause a most agonizing death.

Causes of Noise Pollution

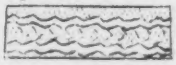
Three major sources of sound cause the most damage to human health. Transportation noises caused by accelerating engines, airplane travel, wind resistance, tires, and so on may damage the health of families living near highways and airports. Industrial noises caused by the pounding of machines, escaping steam, air rushing through engines, construction, etc., affect many people at work and cause some hearing losses. Home noises from loud steros, radios, arguments, blenders, and power tools add to the daily decible intake. These sounds may be particularly irritating when coming through poorly insulated apartment walls during evening hours. Psychologists feel that these apartment noises have increased family break-ups and crimes of violence in large cities.

Noise Control

Most noise can be controlled. Industrial sounds can be muffled, enclosed in sound chambers, and limited by redesigning engines. Where the sounds cannot be brought below the 90-decible level, ear muffs or plugs can be used to protect the worker.

Apartment noises can be controlled with carpeting, drapes, floor plans that do not place family rooms of one apartment against bedrooms of another, insulation between walls and beneath floors, and rules which restrict parties during sleeping hours.

Highway sounds can be controlled by building the road below the land surface.

With this design, the edge of the road absorbs and deflects upward much of the sound pressure. Tires, which cause much noise at high speeds, can be designed with ribs  rather than pockets. At 55 mph, a large truck with pocket-tread tires may make four times the noise of a truck equipped with ribbed treads. Good mufflers also reduce traffic noises. A car or motorcycle without a muffler may create noise over 100 decibles for a listener 50 feet away. The noise levels for the driver may be at levels which can soon cause damage.

Social Issues

Most people think noise means power. A "quiet" jackhammer has been on the market for years, but jackhammer operators seem to feel that noise is necessary to break concrete. The hammer does not sell well. A "whisper quiet" vacuum cleaner was a commerical failure because housewives were convinced that it lacked power. All tests indicated that it had a least equal power to its competitors, but it didn't "sound" powerful. In short, most people think noise means power.

Research also indicates that our world is getting louder, hearing damage is affecting more and more people, and health problems associated with noise are increasing. This hurts society, for much communication is verbal. Ability to find and hold jobs is lost, attitudes toward life are damaged, and medical costs rise as hearing damage grows.

Governments have responded to increasing noise levels with laws controlling loud cars, industrial noises, airplane noises, noises which disturb the peace, and so on. Thus, a combination of growing population, increasing use of machinery, and the feeling that noise is power have brought about the creation of many laws controlling noise levels at work, on the highway, and in the home.

The questions below should be answered after viewing the film, Hearing - The Forgotten Sense, which helps explain many of the concepts in this paper.

Student Self-Test Questions

1) If a very loud motor powered a machine (such as a Banbury or mill), how could the noise be reduced for the men who used the machine?

2) Give two examples which show that people think loudness means power.

3) List three things that can cause hearing loss.

4) How much louder does a sound appear to be when its decible level changes from 80 to 100?

5) How long can you tolerate a sound of 100 decibles without beginning to suffer hearing damage?

6) What sound level will start to cause hearing loss in a human exposed to the sound more than four hours every day?

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Behavioral Objective Number	Topics and Concepts
25	Students shall be able to match the function with a description of Goodyear's sound enclosures.
26	Students shall be able to select from a list of six choices, four factors which will often cause hearing loss.
27	Students shall be able to select the maximum acceptable decible level for an eight-hour working day.
28	Given one decible level, students shall be able to select a level which is four times louder.
29	Students shall indicate a personal preference for quiet machines.

Teacher Suggestions

The film, Hearing the Forgotten Sense, was produced for an adult audience, but the points it makes fit well with this paper. The last part of the film contains a hearing test for your class. The sound level decreases about five decibles between each listening test, and students are asked to raise their hands when they can no longer understand the words. Point out the relationship between the perceived loudness and the decible level. Encourage the students to raise their hands by emphasizing that:
1) loss of hearing is not something you ignore or use to make a fool of a person, and
2) the worth of the test depends on everyone's honesty. If 15 people cannot understand the word, but only two raise their hands, then all 15 will think they have poor hearing.

Goodyear has done an effective job of reducing noise pollution in the plant, and we can no longer show the students a sound level higher than 90 decibles at a work station. Several motors are quite loud and are walled off from surrounding work stations. However, students should not expect a quiet plant--much of our time will be spent at decible levels between 75 and 90.

Answers - Student Self-Test Questions

Q 1) If a very loud motor powered a machine (such as a Banbury or mill), how could the noise be reduced for the men who used the machine?

A Build a sound-absorbing box around the motor; build a sound-deflecting and absorbing wall or baffel between the men and the motor; encourage the men to wear ear muffs or ear plugs to keep the noise away from their eardrums.

Q 2) Give two examples which show that people think loudness means power.

A Cars and motorcycles without mufflers, or with noisy mufflers; people who shout in arguments (particularly when their argument is weak); and pep clubs which try to out shout opposing clubs; all demonstrate this point.

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Q 3) List three things that can cause hearing loss.

A
a) Sudden, extremely loud noises.
b) Long exposure to loud noises.
c) Damage by mechanical means (pencils, etc.).
d) Aging.
e) Damage due to disease.

Q 4) How much louder does a sound appear to be when its decible level changes from 80 to 100?

A Four times louder.

Q 5) How long can you tolerate a sound of 100 decibles without beginning to suffer hearing damage?

A Two hours.

Q 6) What sound level will start to cause hearing loss in a human exposed to the sound more than four hours every day?

A 95 decibles.

POLLUTION CONTROL AT GOODYEAR

Goodyear's policy statement on environmental control says, in part:

> "Goodyear is committed to devote the time, scientific talent, engineering skills and funds necessary to establish the highest standards of environmental control in all of our own facilities, and to foster such standards in the surrounding communities."

This paper will explain the efforts the Topeka Goodyear Plant has made to fulfill the words above in the areas of noise, air, and water pollution.

Noise Pollution Control

Boxes coated with noise-absorbing material are built around many of the noisy engines in the Goodyear plant. These boxes have reduced the noise levels from 100 to below 90 decibles in many areas. High pressure air and steam vents have been equipped with mufflers. Walls have been built around areas with large and loud machines, and new equipment with reduced noise levels is being designed and purchased.

When machines cannot be equipped to work at sound levels of less than 90 decibles, Goodyear will supply ear muffs or ear plugs without cost to its employees. In addition, all employees receive hearing tests, and anyone suffering hearing loss is moved to a quieter job.

WATER POLLUTION

The 4,000 people living in Goodyear eight hours a day use 20-million gallons of water month for drinking, washing, and flushing. This water is cleaned in a $185,000 water treatment plant. The plant bubbles oxygen through the sewage until bacteria and other small organisms have digested nearly all of the sewage.

Goodyear also uses 125-million gallons of water each month to cool the tire rubber in different stages of the manufacturing process. This water is mixed with the cleaned sewage and poured into Soldier Creek. Samples of the final water mixture are collected every two and one-half minutes and tested to make sure that all systems are working correctly.

AIR POLLUTION

The Topeka-Goodyear plant uses only natural gas and oil for fuels. Oil is used only when natural gas is needed for home furnaces and stoves during very cold weather. Both natural gas and oil are cleaner fuels than coal.

The Goodyear plant also uses machines to collect dust from grinding rubber off the tires and from mixing rubber in the Banburies. These dust collecting machines cost about $170,000 and have been used for several years. Other methods, such as large ventilating fans, large vacuum cleaners, and special equipment for handling dust, all help keep air inside the plant clean. Over the years, hundreds of thousands of dollars worth of air ventilation equipment has been installed in the areas where dust and heat are produced.

Pollution Control and Manufacturing Costs

There are many national, state, and local laws regulating noise, air, and water pollution. The Goodyear plant meets, or betters, the laws' requirements for every kind of pollution control. New equipment is designed and installed nearly every year, and over a half million dollars worth of equipment has been added just in the last five years.

Capital is required to add new pollution control equipment, and stockholders look at the expense in several ways:

1) About two cents per tire has been spent on new pollution control equipment over the last five years.

2) Over 125 dollars per employee has been spent to control pollution.

3) The 500,000 dollars could have been spent producing new products, hiring more employees, and modernizing present equipment. Instead, it was spent in a way which did not increase production or profits and continues to use energy and money.

4) The investment in pollution control equipment has made the plant quieter, cleaner, and a nicer place to work. This should attract and hold better employees.

Following your trip, you will be asked to indicate if Goodyear should spend more capital to add new pollution control equipment inside or outside the plant. Consider these viewpoints as you visit the plant.

The slide-tape series "Pollution Control at Goodyear" shows many of the devices mentioned in this paper. Viewing it carefully will help you discuss the questions below.

Self-Test Questions

1) What value does Goodyear receive from a good pollution control program?

2) Why do you think that Goodyear does not treat <u>all</u> of its water in the sewage plant before placing it in Soldier Creek?

3) Should Goodyear be allowed to release any air pollution? Why, or why not?

4) What are two processes which cause air pollution at Goodyear?

5) How are those processes controlled to avoid harming human health?

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Behavioral Objective Numbers	Topics and Concepts
24	Given four possible results of adding pollution control equipment to a manufacturing plant, students shall be able to select the most realistic outcome.
25	Students shall be able to match the function with a description of Goodyear's sound enclosures.
30	Students shall be able to match the function with a description of one of Goodyear's dust collection machines.
31	Students shall indicate that Goodyear is meeting all state and federal laws on air, water, and noise pollution.
32	Students shall indicate that before deciding to install pollution control equipment, the cost of both the equipment and the environmental damage should be compared.

Teacher Suggestions

This paper was designed to pinpoint the major environmental controls used in the Topeka-Goodyear plant. The slide-tape presentation, "Pollution Control at Goodyear," compliments and builds from this paper. The script for the slide series is in Appendix II.

Three broad concepts should be gained as a result of this paper and its discussion:

A) Adding pollution control equipment to a plant aids its reputation and may help retain better employees, but, realistically, it is still a nonproductive use of capital which either decreases profits or raises prices.

B) Before adding pollution control equipment, the environmental damage caused by the pollution should be balanced against the cost of the equipment. Environmental damage should include damage to human health, animal and plant life, scenery, and so on. Cost of the equipment should take into consideration the alternatives of lowered prices, plant expansions, or modernization which could be provided with the same capital.

C) Too often, laws do not allow adequate consideration of point B, since they are usually written to cover all areas equally. Thus, the same production process may cause severe environmental damage in a crowded city, but may cause little harm in sparsely-populated areas. A classic example of this is the auto emission controls, which are desperately needed in Los Angeles but not needed in Silver Lakes, Kansas; yet, the law requires controls on all cars.

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Answers - Student Self-Test Questions

Q 1) What values does Goodyear receive from a good pollution control program?

A
a) Better worker attitude.
b) Better employee health, which aids production and reduces insurance rates.
c) A cleaner, quieter plant, which reduces accidents.
d) Avoids governmental or legal actions which would damage reputations.

Q 2) Why do you think that Goodyear does not treat all of its water in the sewage plant before placing it in Soldier Creek?

A Cooling water is heated but not polluted in the plant. If it was mixed with the sanitary sewage, the six to one dilution would make it very hard to sustain the bacteria and protozoa populations needed to digest the sewage.

Q 3) Should Goodyear be allowed to release any air pollution? Why, or why not?

A Students should use the discussion of the values and liabilities of installing pollution control equipment as a guide. The argument turns on two ideas:

a) How much damage is caused from the dusts and fumes now being released? This can be determined by examining the number of families living near the plant, the amount of dust falling near the plant, and so on.

b) How much would control of the dust and fumes cost? Could it be better spent to improve the wages, enlarge the plant, or improve on present products and production methods?

After students have discussed the questions enough to bring out these concepts, stop discussion until the trip is completed.

Q 4) What are two processes which cause air pollution at Goodyear?

A Mixing the rubber, grinding tires to expose the white sidewall, curing tires, and heating the plant all produce some air pollution.

Q 5) How are those processes controlled to avoid harming human health?

A Sweeping machines, dust collectors on the white sidewall grinder and the Banburies, delivery of dusts through tubes that do not expose it to air, and air vents throughout the building all keep air pollution under control within the building. Burning natural gas and using a tall power plant stack both reduce pollution concentrations outside the plant.

OLD TIRES - WHAT CAN BE DONE WITH THEM?

This year, Topeka's Goodyear plant will make about 8-10 million tires. In the United States, about 100 million tires will be thrown away this year. Over the last 25 years, according to one estimate, almost 1.6 billion tires have accumulated along our east coast.

What can be done with these tires? They do not decay and return to the soil like paper and food do. Tire manufacturers do everything possible to keep tires from decaying, since a decayed tire would not be a safe tire. You cannot burn tires without making thick clouds of thick black smoke. Many tires are put in city landfills and covered with dirt, but this practice is not good because tires keep air spaces and don't let the soil pack down for a long time. Many tires are simply piled in heaps waiting for someone to decide how to dispose of them.

SOME USES FOR OLD TIRES

Recapping - This is the ideal use for old tires. New tread rubber can be put on old tires, and these new tires can be driven again. This saves rubber and oil energy, while helping control the problem of getting rid of old tires. Recapped tires used to have a bad reputation of throwing off the treads. However, in the last three years, new processes have been invented which make a much better re-cread. In addition, a 1972 federal law requires that all retreads meet the same safety standards as new tires.

Recapping will never solve all the problems of getting rid of old tires, but it can help. Tires can only be recapped one time, and only tires with good bodies can be recapped. If every tire was recapped once, we could cut the number of tires thrown away by one-half. However, only one-fourth of our old tires are recapped. Some countries recap three-fourths of their tires.

Ocean Reefs - Several companies are experimenting with baling tires into tightly pressed and tied bundles which will sink into the ocean. They have found that ocean life quickly covers the tires and the bales become very good breeding grounds for fish, and other ocean creatures. However, this plan must be looked at slowly and carefully, for 1.6 billion tires could make a very big change in ocean-dwelling animals' habitats and numbers. Goodyear is helping build two experimental research reefs in Florida to test this use of old tires.

Safety Cushions - Scientists have found that long stacks of tires will stop a car going 55 miles per hour without much damage. They think we could put tires along highways where many accidents occur, and save lives. However, it might take so many tires to do a good job that they would ruin the road's appearance.

Artificial Grass - Some researchers have found that old tires can be chopped up, mixed with green glue, and spread on the ground to make a pretty and strong green carpet. It can be made hard or soft, and it could absorb rain.

Glasphalt - In addition to throwing away 100 million tires every year, Americans also throw away 26 billion bottles. Some people have found that ground-up tires and glass can be mixed with asphalt to make a very good road surface called glasphalt. There are enough tires and bottles thrown away every year to pave a freeway across the U.S. 23 times with this material. Dulles International Airport has been paved with a similar mixture of waste material to test its ability to act as pavement.

Distillation - Old tires can also be heated to 500° C in large vats that do not let air get to the molten rubber. With this process, 100 tires will make about 140 gallons of oil and 1,500 cubic feet of gas (like natural gas). It will also give up a lot of solid carbon which can be used for many things, or buried. The main disadvantage of this process is that the beads must be cut out of each tire before beginning the process.

Burning - Tires burn with 50 percent more energy than coal, but until now, the air pollution problem has been very bad. However, a new process being tried in the Goodyear plant in Jackson, Michigan, will burn whole tires and produce no odor or smoke. In the furnace, even the bead wires are burnt to an ash. The Jackson plant will burn one million tires a year to heat the water in its boilers.

WHY DON'T WE START USING OUR OLD TIRES?

Transportation - It is expensive to carry old tires to the places which can chop up, bale, or heat them, since so much of the space filled by a tire is air. One scientist has discovered a method of freezing the rubber using liquid nitrogen, then cracking it up into little pieces. This could help hauling problems, but it is much too expensive right now.

Energy - It takes lots of energy to tear up, or heat, or freeze, or bale tires. Energy is expensive, and it is becoming harder and harder to obtain. This is why the lights in many cities have dimmed several times this year--they are using more electricity than they are making.

Habits - We Americans - you and I - do not use the tires as well as we could. Right now, no planned method will adequately dispose of the millions of tires made every year. If each American kept his tires at proper inflation, and accelerated slowly, then part of our problem could be solved. We would then use fewer tires. If we all tried to buy recapped tires, this would also reduce the problem. We can also continue to develop tires which wear better and last longer. Finally, we should encourage our politicians, businesses, and highway departments to make laws and decisions which encourage more research in the use of old tires.

SOLID WASTE CONTROL IN TOPEKA

Before answering the questions below, view the slide-tape series, "Solid Waste Control." These slides summarize the laws controlling disposal of old tires and the methods used in Topeka.

Student Self-Test Questions

1) Why is the problem of old tire disposal growing worse every year?

2) List two disadvantages of disposing of tires by burying in landfills.

3) Why should more people buy recapped tires?

4) Which of the proposed uses of old tires looks the most promising to you? Why?

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Behavioral Objective Numbers	Topics and Concepts
33	Students should be able to correctly compare the compressability and decay rates of tires with other materials found in trash.
34	Students should be able to select a promising method for disposing large quantities of old tires without causing environmental pollution
35	Students should be able to select, from a set of four statements, the one best specifying the safety and potential of recapped tires.
36	Students should know that tires do not easily decay.

Teacher Suggestions

A good discussion session is an essential part of presenting this paper. The student self-test questions and the suggested answers will help guide the discussion.

The slide-tape series, "Solid Waste Control," focuses on Topeka's solid waste disposal system, its laws, advantages, and disadvantages. This 10-minute presentation will be a good lead into the film, Garbage Explosion, and the final paper. The script for the slides appears in Appendix III.

Answers - Student-Test Questions

Q 1) Why is the problem of old tire disposal growing worse every year?

A There are more people, more cars, fewer places to make landfills, increasing air pollution, increasing costs of transportation, and energy. In short, more tires, no place to put them, and too much expense to carry them away have all contributed to rising stacks of discarded tires.

Q 2) List two disadvantages of disposing of tires by burying in landfills.

A The major disadvantages are: 1) tires are bulky and do not compress well, so large air spaces are left in the soil; therefore, the landfill will keep settling as water carries soil into the holes left in the tires; 2) since tires decay very, very slowly, their chemicals are not returned to the soil; 3) we are running out of landfill spaces at the present time, and the millions of wasted tires only compound the problem; and 4) tires contain much energy and could be used as fuel if the proper furnaces were built.

Q 3) Why should more people buy recapped tires?

A Every purchase of a recapped tire means that one less new tire needs to be made, and one less old tire will be thrown away. This solution is not a cure-all, since many new tires cannot be recapped (radial tires and damaged tires cannot now be recapped), and tires can be recapped only once. However, recapping can help solve the problem, and a good recap is now as safe as a new tire of the same type (particularly at lower speed limits).

Q 4) Which of the proposed uses of old tires looks the most promising to you? Why?

A Ask for a show of hands indicating support of each method. Have one of the supporting students give his reasons for favoring his chosen method. Allow some in-class discussion of the pros and cons of each problem. Try to direct the class toward support of the "burning for energy" use. This method promises to be pollution-free, to create energy, and to use many tires.

Be sure to point out that this burning is at a very high temperature, and in a furnace especially constructed to burn tires. It would take only 100 of these furnaces throughout the United States to handle the tires we throw away each year. No other nonpolluting disposal method can handle that many tires and produce something useful as well.

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TRASH - NOW WHAT?

As a nation, collecting and getting rid of trash cost us 4.5 billion dollars last year. That is an average of 22 dollars per person. When home and industrial trash are added together, we average five pounds of trash per person per day, and the problem is growing worse. Right now, Topeka people average six million pounds of garbage a month, and this does not count the old cars, tires, and other trash not dumped in the landfill. Trash disposal is Topeka's number one pollution problem.

Throughout the nation, many cities are running out of dumping areas. Topeka had a very hard time finding a site for its new landfill. New York and San Francisco both have very little time left before they must find something to do with their trash. Both have run out of places to put it.

GETTING RID OF TRASH

There are four basic methods now being used to get trash out of our homes and factories.

1) Open Dumps - This means dumping trash on top of the ground. Many small cities and individuals still use this method. It is illegal, because dumping garbage without burying it attracts rats, flies, fires, and more garbage to make the pile look worse. In the Topeka area, we still have trouble with people dumping furniture, limbs, bottles, and other trash in open dumps along our roads. There is a $500 fine for such dumping. The city refuse department will pick up large things like furniture free, if citizens will call, so there is really no excuse for any open dumping.

   You can report illegal dumping by getting the vehicle tag number, description of the car and its driver, and giving this information to the local law authorities.

2) Landfills - These are areas of land where trash is dumped, packed down, and covered with dirt every day. If the landfill is run correctly, it is fairly clean, and the filled areas can be used for building homes and offices. However, as cities grow larger, it becomes harder and harder to find a large open space or hole to dump trash in.

3) Incinerators - are large high temperature furnaces which burn trash and remove the smoke before letting it get into the air. With this method, metal can be recovered and reused and energy from the burning could be used to help make electricity. Incinerators are not places where trash is just burned--it must be heated to a much higher temperature to be more completely burned. In Topeka, regular burning is allowed only in gas or electric fired incinerators approved by our health department. Open burning of papers, leaves, weeds, grass, or any trash is illegal, unless a special permit is obtained from the health department. The only open air burning that is allowed is for cooking foods.

4) Compacting - Japan is using large machines which press garbage into very heavy and tight bales which can be used as building stone foundations and stones for roads. Compared to a landfill, this allows much more refuse to be placed in the same volume.

None of these four methods really let us reuse garbage like we should. All methods work to get it out of sight so that it is out of mind.

USING TRASH

Presently, there are three main ways man uses trash:

1) Composting - is a way of letting kitchen garbage, paper, leaves, sawdust, and cloth break down into humus which can be added to the soil and which will make the soil much richer. This method won't work for all of Topeka's trash, because it is too slow and takes too much space. However, you could compost the leaves and garbage from your home. All that is needed is to stack layers of 4-8 inches of leaves or garbage, an inch of soil, a little fertilizer, and then another layer of leaves and so on. If the stack is stirred once each month, the leaves will be composted in a year and you'll have very good fertilizer.

2) Recycle - paper, metal, and bottles by collecting trash in separate batches and reusing the paper to make new paper, the metal to make new cans and cars, and the bottles to make new glass. The two main troubles with this method are that people are used to piling all of their trash in one can, rather than separating it, and that manufacturers do not buy and reuse the materials they make. For instance, many paper makers are set up to make paper from trees, not old paper. Therefore, it is cheaper for them to cut 17 new trees, than to chop up one ton of old papers and use it. However, America is starting to recycle many things. For instance, half of our lead, copper, and brass is recycled, and almost a third of our aluminum and steel. But it is paper, which makes up half of our trash. We must recycle much more paper to help solve the problem. Topeka now has aluminum and paper recycling centers.

3) Releasing Energy - is a third use for much of our paper, tires, and kitchen garbage. These materials can be incinerated and used to heat water for steam heat or to produce electricity. They can also be distilled (heated without air) to make oil and gas which can be burned or used to make new products. Both of these methods are not as cheap as drilling for new oil or coal and burning that, but they are cheaper than paying to throw away trash and paying to buy fuel.

HOW CAN WE START USING LESS TRASH?

Americans make about twice as much trash as most other people in the world. We buy almost everything in throw-away packages which add to our trash. We buy, for instance, little pencil sharpeners in plastic and cardboard containers larger than the sharpener. We buy milk, soft drinks, peas, catsup, eggs, and beer in containers which end up in the trash. Some people argue that we should make laws requiring the companies to buy back their containers, but is that really the answer? Does your family only buy pop in returnable containers, or do you buy disposable containers? Do you buy food packaged with the least wrapping, or with the prettiest boxes and plastic containers? Have you ever asked the store owners to supply milk in returnable bottles, not cartons? Would your mother buy it if she had the choice? In other words - do you buy things which would encourage manufacturers to use less package material?

Another bad habit of Americans is our searching for new styles and models. Does your family drive and repair your car just as long as possible, or do you try to buy a new car with prettier chrome, neater seats, and a bigger engine every two or three years? Did you fix and repair your old T.V. as long as possible, or did you buy the newest of color T.V.'s? Did you wear clothing as long as it is usable, or do you buy new clothes to be in style and to impress your friends? Everytime

you buy something new, you buy something which took energy and material to make, and which will require energy and space to get rid of as trash.

In summary, trash is becoming a very big problem to America today. We're running out of space to throw it away, and we're not yet reusing it. If every American would start trying to buy things in returnable containers, and things which last a long time, some of our problems would be solved. We must also encourage companies to reuse the paper, metal, and bottles they make, and we can help at home by composting our yard clippings and leaves.

Let's become good buyers and users, not just big buyers and abusers.

Before discussing the questions below, view the film, Garbage Explosion.

Student Self-Test Questions

1) Which methods of getting rid of trash are illegal in Topeka?

2) Incineration, landfills, and compacting all remove trash from our sight. How do these three methods differ?

3) List three things that have caused solid waste disposal to become one of America's biggest pollution problems.

4) How can solid waste disposal create other forms of pollution?

5) How can you help improve the solid waste problem in Topeka?

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Behavioral Objective Numbers	Topics and Concepts
34	Students shall be able to select the most promising method of disposing large quantities of old tires without causing environmental pollution.
37	Students shall be able to select "open dump" as an illegal method of removing trash in Topeka.
38	Students shall be able to match "composting" with its description.
39	Students should be able to select the method of solid waste disposal most likely to cause air pollution.

Teacher Suggestions

This paper should be presented with the film Garbage Explosion and, if not previously shown, the slide-tape series, "Solid Waste Control."

Point out to the students that solid waste disposal laws have changed drastically in the last few years. Open burning is now illegal in Topeka. Open dumps will be illegal throughout Kansas in 1975; they are illegal anywhere in Shawnee County now. These changes are caused because of our population growth and increasing knowledge of the health effects of open dumps and open burning.

Be sure to point out the fact that parents can call our city refuse department to pick up large materials which could not be placed in the normal garbage trucks.

Answers - Student Self-Test Questions

Q 1) Which methods of getting rid of trash are illegal in Topeka?

A Open dumps and open burning, or burning in incinerators which have not been licensed by the city health department.

Q 2) Incineration, landfills, and compacting all remove trash from our sight. How do these three methods differ?

A Incineration - burning trash at a very high temperature.
Landfills - burying trash after packing it tightly. The material will be able to decay slowly under these conditions.
Compacting - smashing trash into very, very tightly compacted bundles. Decay rate is extremely slow.

Q 3) List three things that have caused solid waste disposal to become one of America's biggest pollution problems.

A a) Growing use of disposable containers; b) use of new nondecaying plastics and fabrics; c) growing populations; d) decreasing areas to throw or bury trash.

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Q 4) How can solid waste disposal create other forms of pollution?

A Incineration can cause air pollution. Open dumps can lead to fires, and disease. Landfills may cause pollution of underground water. Composting may release odors. All methods demand energy to get rid of garbage, and energy is beginning to be in short supply.

Q 5) How can you help improve the solid waste problem in Topeka?

A Coors will recycle all aluminum cans and Coors bottles. Students could help by collecting these items and taking them to Coors. The slide-tape series, "Recycling Aluminum," should be shown before the trip if you wish to visit the Lapeka Recycle Center as part of the trip. Its script is contained in Appendix IV.

The Topeka Packaging Corporation will take all cardboard and paper. In batches of 500 pounds or more, they will pay for the paper. Both the Topeka and Lawrence waste paper plant will provide trucks for school paper drives. The Lawrence plant will pay about $1.00 for every 100 pounds of newspaper, magazines, and cardboard. The Topeka plant is not as cooperative, but may be changing.

Littering is a form of open dumping that most people could help curb by being more thoughtful of others.

If all of us just bought less and repaired more, we could reduce the amount of trash that must be disposed.

Encourage students to make their own suggestions for improving the solid waste problem in Topeka. For instance, one group at Highland Park Junior High proposed a "Trash-a-thon" where students would collect pledges for every sack of roadside litter picked up, and the money could be donated to their favorite charity. This is a very good idea if some adult group could spearhead the organization.

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The Field Trip

Topics and Concepts

Behavioral objectives 4-32 will all be reviewed during the trip, as guides follow the directions contained in this paper.

TEACHER SUGGESTIONS

Table of Contents

Topics and Concepts. . . . . .See pages 7-9
Suggestions for use of the two field trip forms. K-1
"Requests to Principal for Field Trip" form. K-2
"Parental Permission" form K-3
Planning for the substitute. K-4
Pre-field trip lecture suggestions K-4
Field trip time line K-4
Directions for trip guides K-5

Using Field Trip Forms

"Request to Principal for Field Trip" form

Three copies of this form must be submitted for each field trip. They should be submitted as early as possible and at least one week prior to the trip. You may use the form on page K-2 in either of two ways: duplicate it the proper number of times, fill in the required information, and turn in to your principal; or obtain the proper number of request forms from your principal and transfer this information to it.

Please invite your principals to attend this trip with you. It will provide them a much better picture of the value of field trips than could be conveyed in any number of words.

"Parental Permission" forms

Duplicate page K-3, and strongly urge your students to have their parents read and sign these sheets. They are quite important to the continued success of this project and in establishing some communication from you to the parents. We need the volunteers that are occasionally picked up with this form, and the community should be aware of what the project and its teachers are doing with their students. We also need the emergency phone numbers in case a student should be hurt.

Have the class fill out the first three blank lines before sending the forms home. Please bring the forms with you when boarding the bus.

THE TOPEKA PUBLIC SCHOOLS
REQUEST TO PRINCIPAL FOR FIELD TRIP
Secondary Schools

Community resources are valuable aids to the instructional program. Careful planning and proper follow-up are necessary in order to make the trip most worthwhile. This form should be properly completed in TRIPLICATE and signed by the teacher and principal. The original copy is filed in the principal's office. The principal shall send duplicates to the office of instruction and departmental supervisor.

School _____ Department Science Subject and Class _____

Date of Trip _____ Leave _____ Return _____ Number of Pupils _____

Description of Trip The class will study the Topeka-Goodyear plant and will make a 10-minute stop at the Lapeka recycling center. The trip will last three hours. Students will be divided into groups of eight or fewer students and will be led by a trained guide.

Objectives of the Trip All students will study Goodyear's production process, laboratory procedures, economics, and pollution control facilities. The field trip experience will expand and reinforce concepts developed through class experiments, papers, and films during the pre-trip and post-trip study of the "Tire Production and Pollution Control" module. Behavioral objectives, classroom material, pre and post-trip tests are included in the module developed by the Environmental Education Project.

Means of Transportation Environmental Education bus

Required Student Cost none

Teacher Signature _____ Date _____

= = = =

The Topeka Public and Parochial Schools
Unified School District No. 501
Environmental Education Demonstration Project
Phone: 232-9374

The_____school science students in_____class will be participating in a three-hour field trip through the Topeka Goodyear Tire and Rubber Company and the Lapeka Recycling Center on_____. For the past two weeks, the class has been studying scientific concepts used in producing tires and controlling pollution. This trip will review and illustrate the new concepts. Transportation and leaders for the trip will be supplied by the federally funded Environmental Education Project.

If you give_____permission to take this trip, please answer the following questions, and give your signature below.

_____
Signature of Parent

Emergency Information:

Home Phone_____

Alternate Phone_____

Doctor's Name_____

Doctor's Phone_____

- - - -

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Planning for the Substitute

The substitute provided by our project is able to present Papers F, G, H, I, and J and the accompanying slides, tapes, and films. Provide the substitute with lesson plans for each class which would allow her to present meaningful and interesting material.

Notify both the substitute and the students of the various discipline tools at her disposal, for many classes prefer to harass rather than learn from a substitute.

Pre-trip Lecture Suggestions

1. Remind students where they will meet the bus and the time for departure and return to the school.

2. Students will be walking for two hours and will walk over two miles during the trip. They should wear slacks and comfortable walking shoes. They should not wear white shoes or loose and floppy clothing which may pick up carbon black in the Banbury area. Students in wheel chairs and on crutches for less than three weeks will not be allowed on the trip.

3. Do not bring bulky items, such as cameras or tape recorders, on the trip. They will add only weight to the visit, and cameras are not allowed inside the plant.

4. Eat a nutritious breakfast and (in case of afternoon trips) lunch. Students with inadequate meals tire out quickly, and grumbling stomachs provide strong competition for constructive learning.

5. Behavior during the trip: a) Groups may be assigned or selected at random by the Environmental Education staff. b) The trip is an intensive learning experience, so come prepared to work and learn. c) No horseplay is allowed. The moving trucks and machinery are too dangerous to allow inattentive behavior. The guides are under strict orders to terminate the trip after issuing one warning. Students will not be allowed to endanger themselves or others.

6. Samples will be picked up during the trip, carried by the leader and given to the teacher at the conclusion of the trip.

7. The plant will smell like uncured tire rubber, and it will be loud in many areas. Goodyear is spending hundreds of thousands of dollars to improve its environment, but it is a very difficult job. Students should expect this problem and focus their attention on the process and products, not the by-products.

Field Trip Time Line

The trip requires a full three hours to reach every objective. If less than three hours is available, portions of the trip and the visit to the Lapeka recycle center will be trimmed from the agenda.

Travel to the plant and disembarking time. . . . . .15-20 minutes
Tour of the plant. . . . . .1 hour, 45 minutes
Review and discussion. . . . . .20 minutes
Visit Lapeka recycle center. . . . . .10 minutes
Travel to the school and disembarking time . . . . .15-20 minutes

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LEADER_____ EVALUATOR_____ DATE_____

Directions for Trip Guides

The field trip for each group will be unique. The class will be divided (arbitrarily) into groups of eight students or less. Each group will have a different leader and a different route, but all will try to meet the same basic goals.

These suggestions should help make the field trip as profitable as possible.

1. Learn the students' names as quickly as possible, and call them by name throughout the trip.

2. Vary your topics and pace.

3. Do not talk to the group until all can hear and see what is being discussed.

4. Frequently ask a question, let students think awhile, then pick a specific student (on a semi-rotating basis) to answer the question. Keep questions moving and random enough that students never know who may be called upon next.

The list which follows describes the activities, allotted times, and suggested topics to be discussed at each point on the trip circuit. A check sheet format is used to help focus attention on the specific trip objectives.

General Safety Precautions: before entering the working area of the plant, give students this information.

_____1. Students must stay close to the guide at all times.
H

_____2. Assign one student as "tail gunner." He is to watch for moving vehicles approaching from the rear and to maintain a compact traveling group.
H

_____3. All movement in aisles should be in double file on the right side of the aisle.
H

_____4. Students should not touch machinery or products unless given specific permission.
H

_____5. Samples may be taken to the bus but will not be given during the tour.
H

_____6. No horseplay is allowed. One warning may be given, then the trip will stop for the entire group unless a teacher is available to remove the offending student.
H

_____7. Point out that you are not a Goodyear employee but have studied the plant for many hours.
L

STOP 1. Steam vent

_____8. Steam is not air pollution.
L

_____9. The Goodyear plant is well within all state and federal pollution laws.
H

____10. Remind students that they must keep a tight grouping for maximum safety and speed.
H

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STOP 2. Beside the fabric rolls

____11. Nylon rolls containing about 1,500 yards of material are treated with the 3-T process. Fiberglass, rayon, and polyester fibers have already been treated when they arrive at the plant.
L

____12. Fabric has more strength and less elasticity than rubber. Fabric forms the plies and belts which give tires the strength to resist rocks and chuck holes.
L

STOP 3. Liquid latex fabric coating area

____13. Liquid latex coats the fabric so that tire rubber will adhere to it.
L

____14. Fabric will be used to make plies and belts in the tire.
H

____15. Fabric is heated and stretched for a measured amount of time to improve its elastic strength and thermal expansion characteristics. This is the Goodyear 3-T process (time, tension, temperature).
L

____16. Point out the fume hoods above the machine and the safety cable around the machine.
L

Note - do not let students approach either the lighted control panel or the liquid latex bath.

STOP 4. At the foot of the stairs leading to the Banburies

____17. Anything touched on the stairs or in the Banbury area will leave a layer of carbon black on you.
H

STOP 5. Beside the treated fabric rolls

____18. What makes the fabric dark? (the liquid latex)
H

____19. Why was the latex added to the fabric? (so rubber would adhere to the fabric)
H

____20. What part of the tire will the fabric become? (plies)
L

____21. What will be done to the fabric before it is built into the tire? (coated in the calender machine and cut on the bias)
L

____22. Carbon black dust is very hard to contain--offer examples or analogies.
H

STOP 6. Raw materials area

____23. Synthetic rubber is produced from chemicals found in oil.
H

____24. There are many kinds of synthetic rubber--elasticity, strength, oil resistance, and wear resistance are all properties which vary.
L

____25. Most rubber in passenger tires is synthetic. Earth movers use more natural rubber, since it is much more heat resistant.
L

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STOP 6. Raw materials area (continued)

____26. Resins and other compounds are used to make tire rubber.
L

____27. Sulfur and zinc oxide are most important additives, since they help cure rubber. Curing provides many of rubber's desirable physical properties.
H

____28. Point out the many ceiling vents removing dusty air from the area.
H

____29. Point out that the dust and fumes removed by air vents go directly into the atmosphere. Ask students if Goodyear should be required to filter all dust and fumes from the air vents. Make sure that they realize that the filter cost would be very expensive and that the environmental damage is slight.
H

____30. Which will help employees and the corporation more--investing capital on pollution control equipment or on new production equipment? Can a clear yes or no always be given?
H

STOP 7. Banbury loading station

____31. Every batch of rubber has a unique recipe for a particular purpose. The compounders follow the recipes.
L

____32. Carbon black is injected directly into the Banburies. Carbon black gives rubber wear resistance.
H

____33. As the Banbury opens, some carbon black may escape. This causes the dust in the area. Air intake vents above the machine remove much of the dust.
H

____34. All workers are supplied dust masks if they wish to use them.
L

____35. What are four methods Goodyear uses to keep this area clean?
L

____36. First and second stage mixtures of rubber are used to make the correct rubber for a particular type of tire part.
L

____37. Pick up a sample of the Banbury pellets as you move to the stairwell.
H

STOP 8. Stairwell leading to the Banbury lay-down station

____38. Review the basic methods used to control the amount of dust in the Banbury area.
H

____39. Review the governmental regulations affecting the Banbury area. (oil regulations affect power and synthetic rubber availability, occupational health and safety regulations, quality control regulations on tires, wage controls, workmen's compensation, import - export controls, and so on)
H

____40. Rubber is released from the Banburies in two forms--sheets and pellets. Pellets are easier to measure, use, and store. The Banbury machines are gradually being converted to producing pellets as capital becomes available.
H

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STOP 8. Stairwell leading to the Banbury lay-down station (continued)

____41. Rubber is hot and sticky when it comes from the Banbury. Heat comes from friction, and uncured rubber is sticky until it is cured. (Use the pellet to demonstrate properties of elasticity and strength.
L

____42. Rubber is coated with soapstone so that it will not adhere to itself.
L

____43. Appoint a quiet, shy student to control the sample bag.

____44. Sound near the lay-down station comes from the Banbury paddles beating the rubber against the machine walls and from the air pressure which opens the machine and forces rubber out. Sound levels will be near 90 decibles, the maximum allowed for people working an eight-hour day.
L

____45. You will be walking directly into a heavily traveled area. Stay alert and tightly grouped.
H

STOP 9. Banbury lay-down area

____46. Examine the heated rubber as it is forced from the Banbury. Review the cause of the heat and the need for the soapstone.
L

____47. Show students the procedure used to obtain and send a rubber sample to the quality control laboratory.
H

____48. Point out the lack of work stations near the loudest sounds.
L

This is the most traveled portion of the route! Keep students tightly grouped and alert.

STOP 10. Rubber mill

____49. Rubber is squeezed and kneaded in the mills until it is well mixed, soft, warm, and sticky. It is then sent to machines which create the various parts of the tires.
H

____50. Green sound control boxes, padded inside with fiberglass, control the noise of the large motors which turn the mills.
H

STOP 11. Calender machine

____51. Fabric coated with latex has rubber squeezed onto it to form the plies for the tire.
L

____52. The thickness of rubber coating the fabric is very carefully monitored and controlled with a computer. The computer purchase required capital and really helps improve the quality of the plies while cutting down on waste.
H

____53. What are the three sources of capital for a company? (loans, profits, and stock)
H

____54. Point out the safety cables around the calender rolls and across the fabric strip.
L

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STOP 12. Stairs leading to Quality Control Laboratory

____55. Ask students what is being produced in the area south of the stairs. (beads)
L

____56. Point out the ventilation tubes above the stairs.
L

____57. Discuss Goodyear's minimum requirements for hiring production workers. (5' 8", 150 pounds, high school education or equivalent)
L

STOP 13. Quality Control Laboratory (Should have used no more than one-half your available time when reaching this point.)

____58. Rubber samples from the Banburies are cured in a press to make a ring and a flat sheet.
H

____59. The flat sheet is cut and placed in containers of water with varying amounts of salt. This gives water a different density in each cup.
H

____60. Will rubber sink or float in high-density water? (float)
H

____61. Why measure density? (quick indication if all ingredients included in the rubber)
H

____62. Rapidly cured rubber rings are pulled a specified distance and the required force is measured. If force and distance requirements are not met, rubber is rejected for intended use.
H

____63. What property is measured with this pull? (elastic strength)
H

____64. U. V. light shines on white sidewall rubber to see if it yellows in the sun.
L

____65. Ask students to name chemicals which both black and white tire rubber contain. (sulfur, zinc oxide, resins, and rubber)
L

____66. Ask students to name a chemical which is not contained in white sidewall rubber. (carbon black)
L

____67. Ask how carbon black helps tires (increases wear resistance) and what replaces it in white sidewalls (titanium dioxide).
L

____68. Ask why this laboratory exists. (Goodyear is able to make sure that all rubber used in tires is of a good quality.)
H

STOP 14. Move into the central portion of the Quality Control Laboratory

____69. Tests on new material, fabrics and wire, and on rubber rejected in the first laboratory visited, are run here.
H H L

____70. Explain the adhesion and torsion tests. Show two pieces of ply stock (or other samples) being pulled apart for the adhesion tests.

____71. Point out the new machine which automatically runs tests for plasticity, elastic strength, and scorching on rubber samples. Bring out the necessity of gaining knowledge throughout your life.
L

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STOP 14. Move into the central portion of the Quality Control Laboratory (continued)

72. Show the elastic strength tests run on the fabric cords, and use the graphs to make sure that students can:

____ a. Determine coordinates for any point on the graph.

H

____ b. Indicate the portion(s) of the graph where increments of mass will cause the greatest increase in length.

H

____ c. Indicate the general trend of the graph expected for pulling two cords simultaneously.

L

____ d. Select, from a histogram, the best measurement to use as the strength for a cord in a sheet of fabric.

H

STOP 15. Chemical testing area of the Quality Control Laboratory

____73. Show chemicals used to mix rubber and the samples awaiting testing. Use the sulfur - cornmeal example to illustrate the importance of this laboratory as an insurance against poor quality materials.

H

____74. Show the area where the oxygen demand of sewage water is tested. Re-emphasiz that Goodyear is meeting all water pollution control requirements.

H

____75. Show the carbon black test, and emphasize its value in increasing wear resistance of tires.

H

____76. Before leaving the laboratory area, ask each student to name one test and indicate its importance to tire production.

H

____77. At this time, guides should know every student's name, and most sentences by the guide should be questions.

H

STOP 16. Quiet area at the foot of the Quality Control Laboratory stairs

____78. What noise level can be tolerated for eight hours without beginning to suffer hearing damage (90 decibles).

H

____79. How much louder is 90 decibles compared with 80 decibles? 50 with 30? 80 with 60? What is twice as loud as 72 decibles? Make sure that every student can associate loudness with decible level increases and decreases.

H

___80. Ask for four things which commonly damage human hearing. (Blows to the head, nerve disease, prolonged exposure to loud noise, aging, and objects inserted into the ear all qualify.)

H

____81. Explain the functions of the tread tuber, mills, and sound enclosures which will be passed as the students walk to the tire building station.

L

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STOP 17. Tire Building Stations

82. Demonstrate the tire components in a quiet and out-of-the-traffic area. Question students to insure that each student understands the following:

____ a) Beads contain wire. Their strength keeps the tire round and on the wheel.
H

____ b) The innerliner is very elastic. It helps seal small holes and increases adhesion of the bead to the wheel rim.
H

____ c) Plies and belts are the ribs of the tire. Their overlapping fibers provide a very strong and flexible, but firm, foundation for the tire.
H

____ d) Treads contain very wear resistant, tough, and elastic rubber. They are coated with a very adhesive glue so they will stick to the plies.
H

____83. Move to the tire building area and explain the sequence used to place the tire components in the tire.
H

____84. Have students name the components and their functions as a second tire is built.
H

____85. Point out that the tire builder makes over 130 tires per day, which means that he is paid about 30 cents per tire. Ask how much profit Goodyear makes for each dollar's worth of sales. (5 cents) Point out that labor gets about 35 percent and the cost of materials and machinery make up about 50 cents of each dollar's worth of sales.
H

STOP 18. Tire jammer and lubricant spray area

____86. A spray made of carbon black, powdered rubber, and a solvent helps reduce adherence between the tire and the curing press.
L

____87. Note the protective gloves and the fume hood which protect the health of the operator.
L

____88. Encourage students to pick up an uncured tire. Identify the sidewall, tread, bead, innerliner, and builder number.
H

____89. Review the tire properties which will change during curing. (adhesion, elasticity, shape, tread pattern, density, etc.)
H

____90. Ask students to carefully observe the curing press area and to suggest things which they would want changed if they were to become curing press operators.
L

STOP 19. Tire Curing Presses

____91. Explain how the curing presses operate, with emphasis on the formation of the tread pattern and value of the air-release tubes.
H

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STOP 19. Tire Curing Presses (Continued)

____92. Point out the need for blowing air under high pressure through the air-release tubes and the difficulty in muffling the sound.
H

____93. Ask if the tires can be torn up and reused if something goes wrong. (NO!!! The rubber has changed its properties, and it now has cords and metal beads mixed in. It's like a cake - once baked, it can't be returned to batter.)
L

____94. Ask students what chemicals enable the rubber to change so many physical properties after it is heated. (sulfur)
L

STOP 20. Outside the dust collecting area

____95. Describe the process used to expose white sidewalls on the tire, and point out the dust collection tubes.
H

STOP 21. Dust collector

____96. Describe the mechanism used to separate dust from the air. Ask if the dense dust will sink or float.
H

____97. Ask what should be done with the dust. Encourage suggestions; such as, use as a fuel in a high-temperature incinerator, use as a soil conditioner, and place in a landfill.
L

____98. These machines make well over 90 decibles of low-frequency noise. Ask the students if Goodyear should make them quieter. They should realize that no one works in the area, and the machines are enclosed by walls to cut down on noise into the factory.
h

STOP 21. Tire inspection and discard area

____99. Tire inspectors look for over 100 different defects in tires. These defects may range from pinched beads and thin innerliners through out-of-round tires. Tires are repaired, if possible, and discarded, if not.
H

100. Examine one of the tires in the discard stack. Make these points:

____ a) Tires should be cut in half, since whole tires will not compress and will not decay. If whole tires are buried, landfills will settle for many years until the soil fills in the hollow tires.
H

____ b) The most promising method for disposing and using old tires is burning them in high-temperature incinerators.
H

STOP 23. Beside the Tire Shaving Machines

___101. Point out the mufflers on the compressed air release valves.
L

STOP 24. Whole Tire Test Laboratories

___102. Explain the endurance test. Point out that this tests the adhesion of treads to the carcass, the endurance of the tread rubber, and the thermal expansion rates of the tire components.
H

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STOP 24. Whole Tire Test Laboratories (Continued)

___103. The plunger test measures the strength of the plies. (Innerliners and treads are not usually punctured.)
H

___104. The bead breakaway test measures how much force is needed to pull the bead away from the tire. This indirectly measures the adhesion of the innerliner to the wheel and the torsion resistance of the bead.
H

___105. What would happen when the bead breakaway test was done? (air would escape from the tire)
H

___106. What kinds of driving conditions would give tires these tests?
Endurance - continuous summer driving
Plunger - chuck holes and rocks
Bead breakaway - hitting curbs with the edge of the tire
L

___107. Which test would retreads have the most difficulty passing? (endurance)
Point out that all retreads would need to be able to pass that test.
H

___108. Must every tire produced pass these tests? (No - only five out of every 20,000 and the first five produced for each new type of tire. The tire cannot be sold after being used for these tests.)
H

STOP 25. Earth mover tire curing section

___109. Ask students to explain how they would prepare the tires for curing.
a) insert an air bladder
b) get the uncured tire into a tire shape
c) put it into a mold
d) pressurize and heat the tire until it is cured
L

___110. Three additional steps are needed:
a) The uncured tires are punctured many times with a needle to allow the rubber to cure better and to "breathe" during the curing. This allows air trapped during the tire building to escape.
b) The molds are pre-heated so that the rubber can be heated in a more uniform way.
c) The rubber must cure much longer (up to 17 hours instead of 15 minutes for car tires).
L

___111. The cost of starting business is very great. This section was built in 1956, and it produced tires until 1969 before it finally made enough money to pay for the equipment.
L

STOP 26. Administrative area survey

___112. Point out other career opportunities at Goodyear. Lead a quick tour of the data processing and engineering areas.
H

Review Session

Conduct a review session under a game atmosphere. Try to discuss the major objectives of the trip during this session.

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113. List each stop where the students were unable to see the process being explained.

114. List each stop where students were unable to hear the guide.

115. Was the guide using vocabulary appropriate for your students? If not, list inappropriate words.

116. Did the guide make the trip interesting for the students? Please suggest any needed improvements.

117. Did the guide pace the walking speed so that all students could keep up?

118. Did the guide keep the group together and alert for traffic throughout the trip? If not, where did the problem occur?

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Manufacturing at Goodyear

15 minutes
45 slides

Slide Description	Narration
Title Slide	1. This presentation will help you understand the manufacturing processes used at the Topeka Goodyear plant. During your field trip, you will see many of the men and machines shown.
Topeka Goodyear Plant (Aerial view from the east.)	2. This is the Topeka Goodyear plant. The arrow points to the building you will visit. This plant produces more types of tires than any other Goodyear facility. It has over ten city blocks under its roof and over 4,000 employees. The first building was constructed in 1944, and there have been many additions since then.
Tires	3. The Topeka plant manufactures only tires, making about 25,000 tires every day. Over a year's time they make 1,200 different kinds of tires ranging from the small automobile tire to the world's largest tire for earth movers.
Goodyear Power House	4. This tire production requires large amounts of fuel, electricity, and water. This power house uses enough natural gas or oil each day to heat one-tenth of Topeka's houses. Enough electricity is used to light half the homes in Topeka, and enough water is used to supply a tenth of our homes.
Middle East Map	5. The Goodyear organization is one of the 20 largest companies in the United States. The Topeka plant is one of 112 Goodyear facilities throughout the world. Other plants, such as this one in Morocco, manufacture such products as plastics, fabrics, enriched uranium, aviation products, chemicals, and shoe heels.
Natural Rubber	6. The tire manufacturing process starts with raw materials. This natural rubber is from Indonesia--one of Goodyear's five rubber plantations.
Rubber Tree Tapper	7. Other rubber plantations are located in Guatemala, the Philippines, and Brazil.
Synthetic Rubber	8. There are many different kinds and colors of synthetic rubber. This synthetic rubber is made from petroleum at another Goodyear plant. Most of the rubber in passenger tires is synthetic.

Railroad Car

9. This railroad car contains tons of carbon black. Carbon black is nearly pure carbon produced by burning natural gas without enough air and collecting the soot. Carbon black gives rubber the ability to withstand wear. Without it, the tire tread would be like the rubber eraser on a pencil and would wear out quickly.

Carbon Black Tower

10. Every tire requires almost two kilograms of carbon black. Carbon black dust is very hard to control. Because of this, Goodyear pipes the carbon black into this tower, and delivers the dust directly into the Banbury mixer. The dust is never intentionally exposed to the air inside the plant.

Chemical Drawer in Lab

11. Many kinds of chemicals are required to give each kind of rubber its particular properties. This man, and his fellow lab workers, test each shipment of all raw materials coming into the plant. They make very sure that the chemical is what was ordered before releasing any of it for use in the plant. They act as an insurance policy against low-quality materials.

Rubber Cutting Machine

12. After each material has been checked, the Banbury operator begins to prepare the mixture of materials necessary for making tire rubber. This man is cutting and weighing blocks of synthetic rubber.

Banbury Loading Sheet

13. Carefully weighed amounts of sulfur, zinc oxide, and other chemicals are used to make tire rubber. These materials are measured and placed on a conveyor belt which carries them to the mouth of the Banbury machine.

Mouth of the Banbury Machine

14. The Banbury machine works like a huge egg beater to mix the rubber and other materials. As the rubber, oils, and chemicals enter the Banbury, some carbon black may fly up from the mouth of the mixer. Air vents beside the mouth collect most, but not all of the carbon black. Large floor sweepers and ceiling vents also help capture the carbon black and allow the Banbury area to meet governmental health standards for dust and safety.

Slurry Tank

15. The mixed rubber is released from the Banbury in a continuous sheet about one and a half meters wide and three centimeters thick. The rubber is very sticky when it comes from the Banbury at the top of the picture. The next step is to pull the rubber through a white bath containing a mixture of soapstone and water. The coating keeps the rubber from adhering to itself.

Wigwag Stack	16. After the rubber coated with soapstone has cooled, it is stacked in wigwag fashion.
First-Stage Stack	17. Some rubber may also be stacked in flat sheets. This rubber must be mixed twice before the complete combination of materials is made. This rubber is from the first-stage mixing.
Quality Control Rubber Press Room	18. A small sample of every batch of Banbury rubber is sent to the Quality Control Laboratory. Here, the rubber is rapidly cured into a ring and a flat sheet. The man here is about to put a rubber sample between the metal jaws of the curing press. The two machines with the big dials on the left will be used to test the elastic strength of the cured rubber rings.
Density Testing	19. The flat sheet of rubber cured in the press is cut into small pieces and dropped into liquids with different densities. The rubber will float if its density is too low or sink if the density is too high. By using the density, strength, and elasticity tests, the operator can determine if the rubber was mixed correctly.
Main Quality Control Room	20. The laboratory results are quickly sent back to the men waiting to use the slabs of Banbury rubber. The rubber will be released for use if it passes the tests. If the rubber was mixed incorrectly, very careful tests are run on fresh samples in this room. These tests will determine how to make the rubber usable.
Mill	21. When the Banbury rubber is released for use, its next step is always to a mill such as this. The mill squeezes the rubber between two big rolling cylinders until it becomes soft, adhesive, and ribbon-like. Then the rubber is sent to a variety of machines, depending on its eventual use.
Belts and Plies on Step-Down Tire	22. If the rubber is to be used to make plies or belts for the tire, it is sent to the calender machine.
Calender Machine	23. In the calender machine, a brown sheet of fabric is pressed against a calender roll covered with soft rubber. The rubber is squeezed into the fabric and forms a layer over the fabric sheet.
Plies Roll-Up Stock	24. The rubber-coated fabric for plies is cooled and rolled up between layers of cloth. The cloth keeps each layer of rubber separated from other layers until they can be built into a tire.

Cut-Away Tire Diagram

25. The fabric coated with rubber had its threads running in straight lines. Most tires use the fabric running at angles to give the most strength and flexibility.

Bias Cutting Machine

26. This man cuts a long, diagonal strip off the rubber-coated fabric produced by the calender machine. He turns the fabric and sticks it back together on an angle, or bias. Each cord of fabric now runs at an angle across the strip of ply. This rubber-coated fabric is again rolled up between sheets of cloth and is carried to the tire builder.

Step Down Tire

27. In addition to plies, tires also have thick layers of tread rubber and thinner layers of rubber covering the sidewalls. This rubber is made by a tread tuber machine. This machine is so big that a picture cannot be taken of it.

Bead Wrapper

28. Strands of copper-coated steel wire are used to make the beads in a tire. This man runs a machine which coats several strands of wire with rubber, rolls it up, and wraps the wire to make the bead.

Tire Builder

29. When all of the parts of the tire are made, the tire builder begins to build the tire. The parts of the tire are rolled onto an inflated drum and are sealed together. The drum shrinks as it is deflated and the barrel-shaped tire is removed. The tire builder tosses the tire over his head onto the metal conveyor belt arms. These arms will deliver the tires to the curing press.

Curing Press

30. The top half of the curing press machine will lift up and the barrel-shaped tires will be placed inside metal molds. The machine will then close and press the tire into the molds.

Open Curing Press

31. The curing press operator is like a cook who takes batter, places it in a container with the proper shape, and gets an angel food cake, or a waffle. What is cured (or cooked) depends upon the batter and the shape of its container. In the upper part of this picture, you can see the top half of the metal press which shapes and heats these tires. In just 15 minutes, these molds will permanently change many of the physical properties of tire rubber.

Visual Inspection Line

32. A careful visual inspection of every tire is made for 99 different types of tire defects. With this check, pinched beads, poor curing, innerliner weakness, and other defects are spotted.

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Balance Check Area	33. The tires are given a careful set of checks for proper balance by the machines with red lights on the right side of this picture. Then, the tires are classified according to size and construction, and placed on the wagons to the left.
Tire Wagons	34. These wagons carry the tires to the tire warehouse.
Setting up the Endurance Test	35. Before any tires can be released for sale, a few samples must be checked for five tests. This is the endurance test. The tire is pushed against the fly wheel on the left by the lead weights on the right.
Monitoring the Endurance Test	36. The room temperature for the endurance test is kept at 100° F. The tire is run continually at 50 miles per hour for over a day and a half. Then the speed is increased. This man checks the gauges indicating the speed, temperature, and pressure on the tire.
Bead Break-Away Test	37. The bead break-away test measures the force required to pull the bead away from the edge of the tire rim.
Plunger Test	38. The plunger test measures the force required to push a 2 cm. wide steel plunger through the tire's plies.
Warehouse	39. Only after the sample tires have been thoroughly tested are the rest of the tires released from the warehouse to be sold.
Earthmover Tire Building	40. Goodyear also builds large earthmover tires. These tires will take two men from two hours to 24 hours to build. These men are wrapping the plies around the beads on this earthmover.
Earthmover Tire Building	41. After each layer of plies is added to the earthmover, the operator must apply lubricating wax to aid in pulling on additional plies. As the tire revolves, this man presses two pieces of wax against the plies. Large earthmover tires may have 42 plies.
Uncured Earthmover Tire	42. This is the uncured, earthmover tire containing over a ton of rubber.
Earthmover Tire Curing Presses	43. The uncured tires are forced into a tire shape by an air bladder shaped like an innertube. The tires are then placed inside the large metal mold in the middle of the picture. This mold is heated under the large steel dome until the tire is cured.

Stacked Earthmover Tires

44. Samples of these earthmover tires are given careful examination, both visually and with X-ray, before being shipped and sold.

Goodyear Plant

45. In summary, the Topeka Goodyear plant uses energy, raw material, and men to produce 25,000 tires every day. This plant produces 1,200 different kinds of tires, ranging from the giant earthmover to small tractor tires. Quality Control Laboratories insure that each kind of tire will be made correctly.

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Pollution Control

12 minutes
20 slides

Slide Description	Narration
Pollution Control at Goodyear	1. This series of slides will show some of the methods used to control pollution while tires are being manufactured and after they have been used.
Calender Duct Work	2. Dust and fumes inside the plant are two of Goodyear's concerns. Vent systems are installed throughout the plant to help remove heated air and gases. The triangle is on one of the ducts which removes air from above the calender machine.
Carbon Black Tapper	3. In the Banbury area, carbon black dust is very hard to control. This man is checking one of the chutes that injects carbon black directly into the Banburies. The dust is never intentionally exposed to the air.
Air Vents on Banburies	4. When the Banbury opens for loading, some carbon black may escape. Air intake vents on either side of the Banbury's mouth suck up much of the dust.
Sweeping Machine	5. The dust which is not trapped by the air vents on the Banburies is collected by several vacuum sweeping machines such as this one.
White Sidewall Grinders	6. To make white sidewall tires, black rubber must be ground to expose the whitewall. Grinding rubber makes dust. The large pipes supply a strong vacuum to suck dust up from the machine.
The Dust Collecting Machine	7. White sidewall grinder dust enters this machine from the pipe at the left. The dust is blown into water and sinks to the base of the machine. Slowly moving paddles carry about 1,000 pounds of dust to collecting wagons daily.
Goodyear's Smoke Stack	8. Goodyear causes very little air pollution. Some dust is released by air intake vents, but the amount is small. The plant burns natural gas (a very clean fuel) except during cold weather when they use oil. Harmless steam from water cooling towers evaporates and looks like white clouds above the plant on cold days. Goodyear meets all current State and Federal air pollution requirements outside and inside the plant.
Sewage Plant	9. After water is used in Goodyear, it is treated in this sewage plant.

Sewage Plant Aerating System	10. In the plant, air is bubbled through the sewage to allow bacteria and protozoa to destroy the sewage.
Water Testing Lab	11. Samples taken from the sewage plant are collected and tested daily to determine how much oxygen will be required to completely clean the water. This gives a good indication of the efficiency of the sewage treatment plant.
Water Entering Soldier Creek	12. The clean sewage water is mixed with large amounts of clean, cool water and added to Soldier Creek. This process enables Goodyear to meet all current State and Federal water pollution requirements.
Early Sound Enclosure	13. Sound pollution is another area of concern for Goodyear. This wooden box surrounds a loud engine which turns a rubber mill. The pollution control engineer is measuring the decible level with a noise meter.
Interior of Sound Enclosure	14. The interior of the sound enclosure is covered with thick layers of fiber glass matting to help absorb the sound.
New Sound Enclosure	15. Sound enclosures now cover most loud engines and have reduced the sound level to below 90 decibles. Man can safely work for eight hours a day in areas with this noise level.
Small Mufflers	16. To help control loud sounds, mufflers may be used. These small mufflers control the whistle of air released under pressure.
Tread Tuber Machine	17. Not all machines, such as this high pressure tread tuber, can be enclosed by sound barriers or muffled. Many loud machines require constant control by people; therefore, Goodyear provides its employees ear muffs and pays for custom-fitted ear plugs. Goodyear has also been purchasing machines engineered for relatively quiet operation.
Pile of Tires	18. Goodyear is also concerned about solid waste disposal. The 6.5 million tires that the Topeka plant makes each year must eventually be thrown away by those people who buy them.

Jackson, Michigan, Plant

19. Goodyear, as a company, has pioneered many uses for old tires. They have experimentally produced glasphalt and fish nurseries from discarded tires. The most promising new development is the use of a mammoth tire-burning furnace that burns over a million tires a year. This furnace supplies energy for this Goodyear plant in Jackson, Michigan.

Topeka Goodyear

20. In summary, air, water, and noise pollution accompanies tire production. Topeka's Goodyear plant has controlled these problems and meets all Federal and State requirements for pollution control. In addition, the corporation continues to try to control solid waste pollution from the tires it makes and sells.

Solid Waste Control

5 minutes
23 slides

Slide Description		Narration
Solid Waste Title Slide	1.	Solid waste pollution is the most costly pollution problem facing Topeka. Disposing of solid waste is expensive and is growing more expensive.
Open Dump By Road	2.	Many people simply discard their trash along a road. These open dumps are illegal anywhere in Shawnee County and violators may be fined $500. Rats and mice breed in these piles and carry several human diseases.
Table Rock Open Dump	3.	This pile of material was dumped around Table Rock Lake in Missouri in just three months. Similar piles could be built from trash dumped around Lake Shawnee.
Burning Tires	4.	Trash cannot be burned in the open without causing heavy air pollution. Open burning is illegal within Topeka's city limits, so another means must be used to get rid of trash.
Kupp Landfill	5.	The method of dispocing of old tires used by Goodyear and the city of Topeka is to bury them in a landfill.
Landfill Operations Summary	6.	In a good landfill, garbage is spread out into a thin layer, compacted, and then covered with a thin layer of dirt.
Landfill Cell Slope	7.	To prepare the landfill, a gentle slope is needed.
Tractor Compacting Trash	8.	A thin layer of trash is then spread and compacted on the slope.
Cell Working Face Cover	9.	After many thin layers of garbage have been compacted together, at least six inches of soil are laid down over the outer edge.
Layered Cells	10.	If more than ten feet of trash is to be added in the landfill, a layer of soil at least one foot thick must be placed between layers of trash.
Top Cover	11.	The top layer of trash is covered with at least two feet of soil.
Settlement Graph	12.	After about five years, most of the decayed matter will settle. Tires will continue to decay at very slow rates for years to come. Plastics, glass, and aluminum may never decay.

Playground	13. Five years after the landfill is completed, playgrounds can be constructed on the site.
Office Building	14. After ten or more years, small buildings and homes may be built over the landfill.
Hupp Landfill	15. The sanitary landfill is one way to turn waste land, such as oil quarries, into productive areas once again. However, in practice, landfills have some disadvantages.
Refrigerators and Stoves	16. Hollow things, such as stoves, refrigerators, and tires, cannot be easily compacted. This causes the landfill to settle for many years. Trash surrounding the hollow spaces in tires moves very slowly to fill the available air spaces.
Tractor Compacting Brush	17. Brush, and particularly large trees, are also difficult to compact.
Water Standing in Trench	18. Seeping ground water may hinder landfill operations by causing tractors to get stuck.
Water Seeping From Landfill	19. Even worse, if the landfill is poorly designed seeping water may carry poisonous chemicals into water supplies of people or animals.
Papers on Protective Fences	20. Blowing paper may be a problem for surrounding neighbors if protective fences are not erected.
Gases Produced by Landfill	21. Some unpleasant gases are also released from the landfill. If not controlled, the hydrogen sulfide and ammonia may damage plants growing on the landfill.
Incinerator	22. Alternatives to landfills are being developed by many people. Carefully controlled incinerators may be useful to some of the large stores in town. However, incinerators that can handle all Topeka's trash and allow us to efficiently recycle metal and glass have not yet been designed and successfully tested on a large scale.
Landfill	23. Other ideas, such as composting, are still being developed; but, despite its many disadvantages, the landfill is still the most inexpensive way to dispose of large quantities of waste materials for a city like Topeka.

Recycling Aluminum

7 minutes
32 slides

Slide Description	Narration
Mass Cans in Motion	1. No narration. (can sound effects)
Same slide with less cans.	2. (Reduce volume of sound on each slide.)
Same slide with less cans.	3. (Reduce volume of sound on each slide.)
Recycle	4. Adolph Coors Company has reclaimed millions of pounds of aluminum with their cash-for-cans program.
Recycle - For Better Environment	5. At an average of 24 cans per pound, well over one billion cans have been collected since the program started in 1970.
Keep America Beautiful	6. People have received nearly three million dollars for collecting cans.
Complete Symbol	7. Yet billions of cans were thrown away and millions of dollars went uncollected because many people did not take the time to recycle their cans.
Current Shot of Brewery	8. Coors, in announcing its commitment to buy <u>any</u> aluminum beer cans states ..."Because aluminum can be melted and used over again, it amounts to the recycling of a natural resource and it helps keep America the kind of place we all want it to be."
Graphic Unfinished Can Superimposed	9. In order to fully appreciate the value of recycling, let's quickly follow just how an all-aluminum can is manufactured, used, and recycled.
Aluminum Rolls	10. Aluminum ingots are rolled out into sheets and then wound into a roll.
Stamp Machine	11. Rolls of aluminum are fed into a stamping machine and cut into round, flat discs.
Stretching Can	12. The disc is pressed into a cup and then formed into the basic can by stretching out the walls to the proper height. The top is trimmed and the can made ready for decorating.
Litho Machine	13. This high speed lithographing machine prints the can after it is formed by rolling the colors on one at a time, one color on top of the other.

Cans Coming Out of Drying Oven	14. Every can is sprayed internally with a lacquer to prevent any transfer of metallic taste to the product. It is then conveyed through a drying oven.
Car on Conveyor	15. The cans are stored and then transferred in bulk to the brewery where they are rinsed and fed by conveyor belt into the packaging building. They are filled with beer, lids rolled on, and the cans are conveyed to packaging assembly lines.
Reclaimed Cans in Canvas Bag	16. Once the cans are sold, Coors can no longer control their fate. They must depend on the buyer to save the cans and return them for recycling.
Superimposed Can on Print	17. It is <u>most</u> important that all cans be returned. Compared with other cans and bottles, making aluminum cans from ore uses twice as much energy. Aluminum cans made from recycled aluminum use only one-tenth as much energy to produce. Every pound of recycled aluminum saves energy for other uses.
Sick Animal	18. In addition, deer and other animals swallow pull tabs and cans shredded by mowers. Sharp pieces of metal slice open stomachs and endanger many kinds of wildlife.
Small Boy with Bag of Cans	19. Each of us should pick up, crush, and recycle aluminum cans to a reclamation center.
Boy Signing Receipt	20. At the reclamation center, the customer is given a receipt for his aluminum and the cashier pays cash for the amount shown on the receipt.
Baled Aluminum	21. The cans are weighed and stored in large trucks until they can be baled and made ready for shipment to a large aluminum smelter.
Shredded Aluminum Being Poured	22. At the smelter, the aluminum is fed into a furnace.
Furnace	23. The impurities are removed and the metal is converted into a molten state.
Row of Ingots	24. It is then poured into ingots.
Ingot on Forklift Truck	25. The ingots are stored until the aluminum can be made into new cans, paint pigments, aluminum siding, lawn furniture, or other similar items.

Glass Bottles Piled Up	26. Coors bottles are also returnable, with a value of one cent each. Bottles in good condition are cleaned and filled with beer again. Chipped and faulty bottles are ground up, melted, and made into new bottles or used to make paving materials.
Mass of Cans in Trailer	27. Efforts are underway to recycle not only aluminum and glass, but also wood, paper, metal cans, and many other materials.
Committee Organizational Chart	28. Adolph Coors Company plans to be in the forefront of the fight against litter and solid waste problems. However, company effort can not succeed unless all of us support the recycle effort.
School Kids Clean Up	29. Schools can collect aluminum and Coors bottles to raise money for clubs, field trips, or parties.
Man and Woman Behind Truck	30. The Animal Humane Association of Albuquerque is paying off its building by having people save aluminum cans for them.
Barrel Inside	31. The Colorado Boys' Ranch painted barrels and set them in 78 grocery stores throughout Denver. In just one year they collected over 150,000 cans and made $700.
Aluminum Containers	32. There is nothing wrong with collecting aluminum cans and bottles to earn money to spend as you wish. Everyone's effort can help save energy while making the world a little better for all of us.

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ELASTICITY AND STRENGTH OF RUBBER BANDS

Rubber Band #1
Description

_____

_____

Mass	Length

Rubber Band # 2
Description

_____

_____

Mass	Length

Graph

Length of rubber band units =

Mass added to rubber band units =

ELASTICITY AND STRENGTH OF RUBBER BANDS
Graph

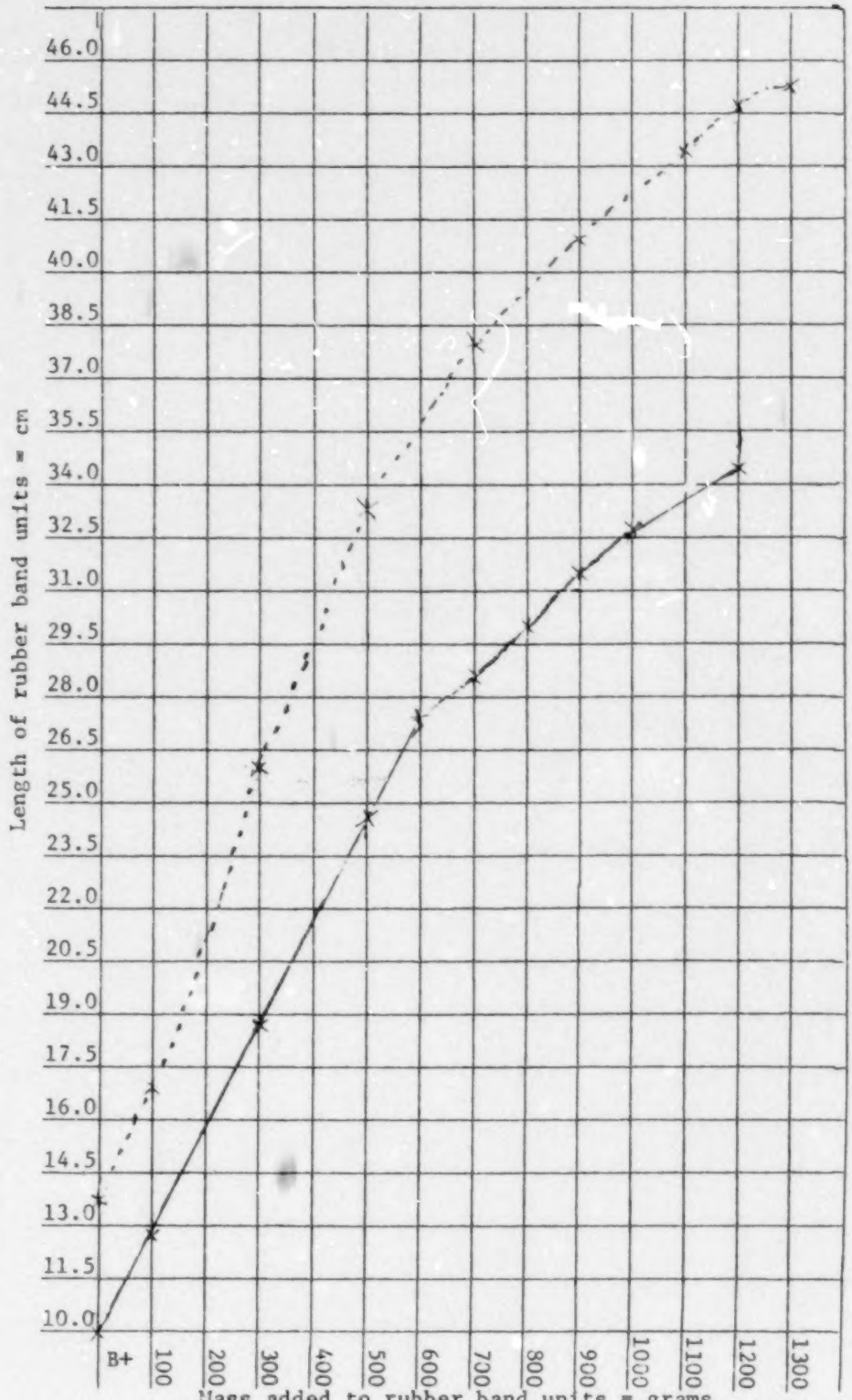
Rubber Band #1
Description
3 mm - new rubber band

Mass	Length
Bucket	10 cm
B+ 100gm	12.5cm
B+ 300gm	18.8cm
B+ 500gm	24.7cm
B+ 600gm	27.7cm
B+ 700gm	28.7cm
B+ 800gm	30.0cm
B+ 900gm	31.5cm
B+ 1000gm	32.7cm
B+ 1200gm	34.7cm

Rubber Band #2
Description
Above rubber band - stretched 20 times

Mass	Length
Bucket	13.5cm
B+ 100gm	17.0cm
B+ 300gm	26.0cm
B+ 500gm	33.4cm
B+ 700gm	38.0cm
B+ 900gm	40.7cm
B+ 1100gm	43.7cm
B+ 1200gm	44.6cm
B+ 1300gm	45.0cm

——— = Graph of the new 3 mm rubber band.
----- = Graph of above band after 20 stretches.



Optional Graphing Exercise

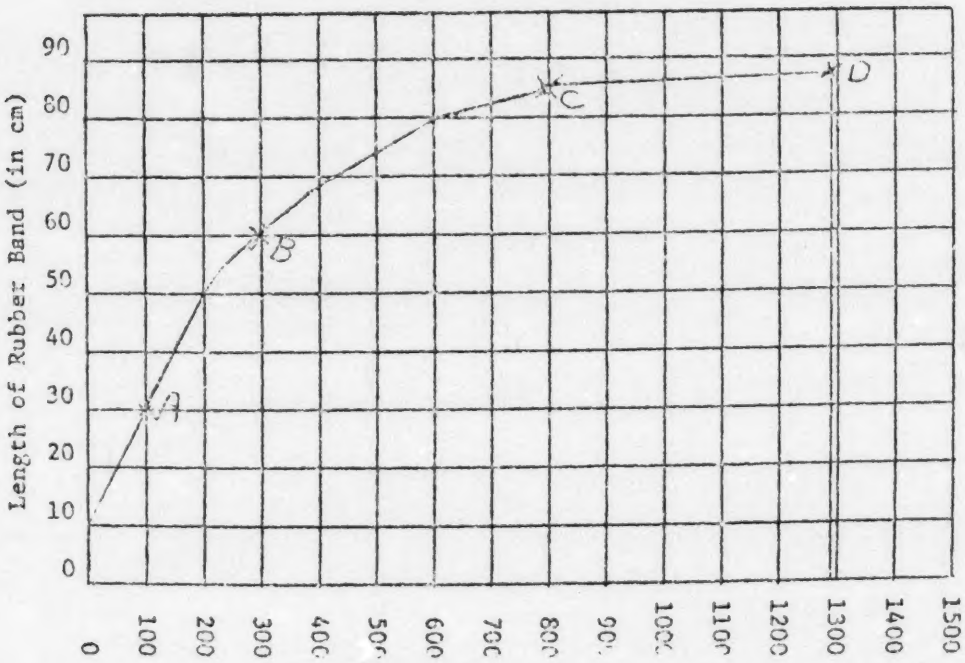


Figure 1. Elastic Strength of One Rubber Band.

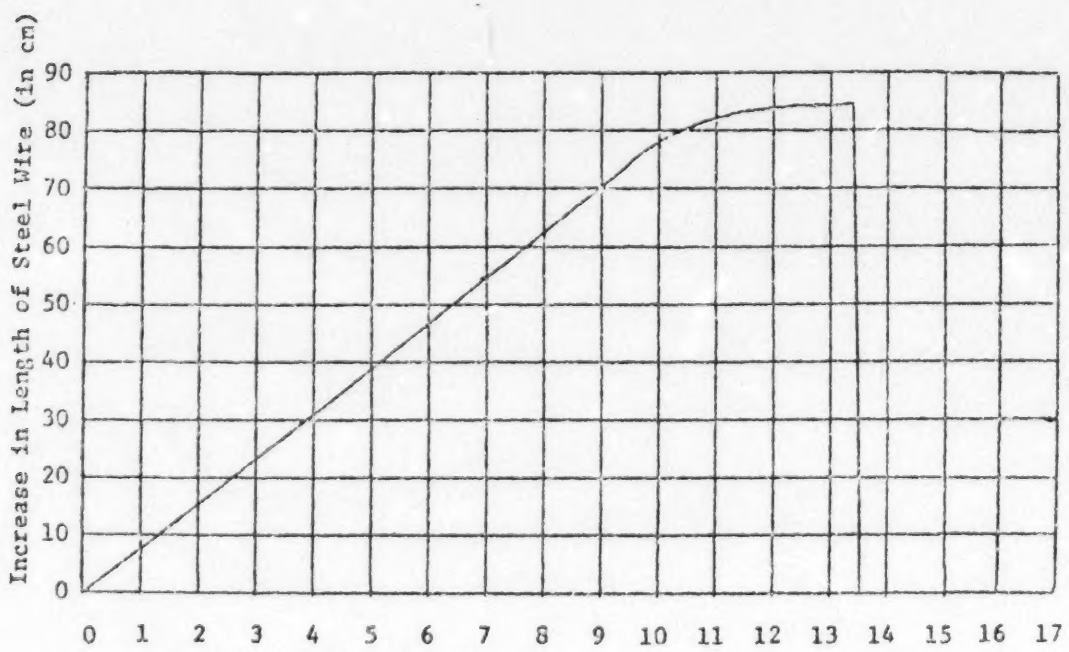


Figure 2. Elastic Strength of One Steel Wire.

Module: 1

Transparency 4
Paper E

ADHESION OF TAPE

Tape Description

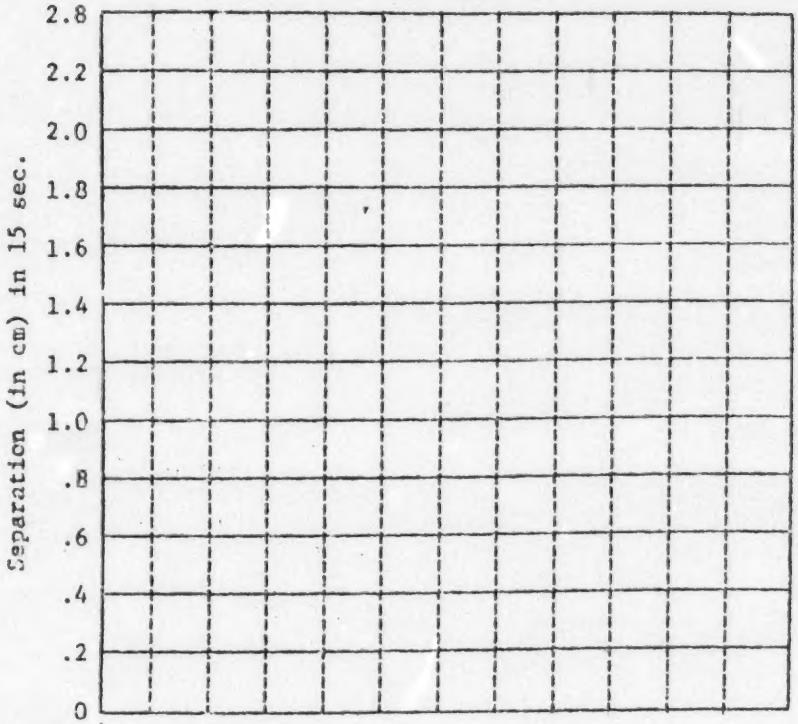
_____

_____

Adhesion of _____ tape

Distance separated 15 sec	Total Mass

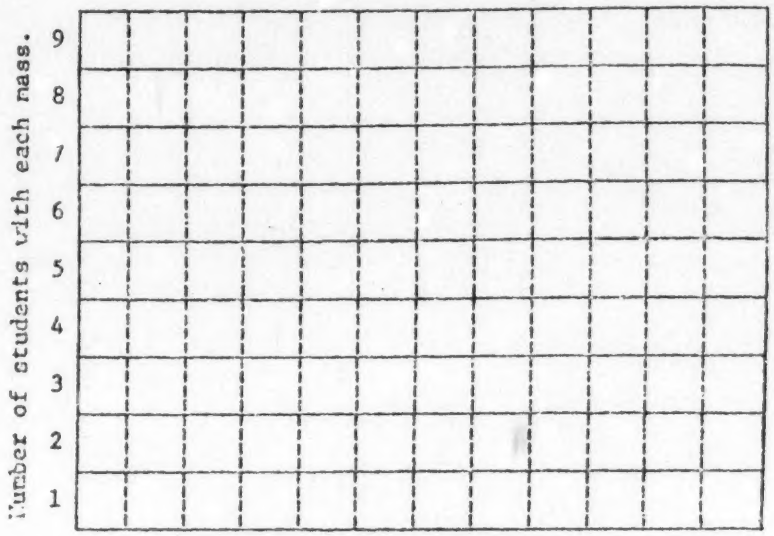
Mass required to separate 1 cm in 15 sec =



Mass used to achieve separation in 15 sec.
Units of mass = _____

Class Results

Mass for 1 cm separation in 15 sec



Mass needed for 1 cm separation/15 second units = _____.

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Module: 1

Transparency 5
Paper E

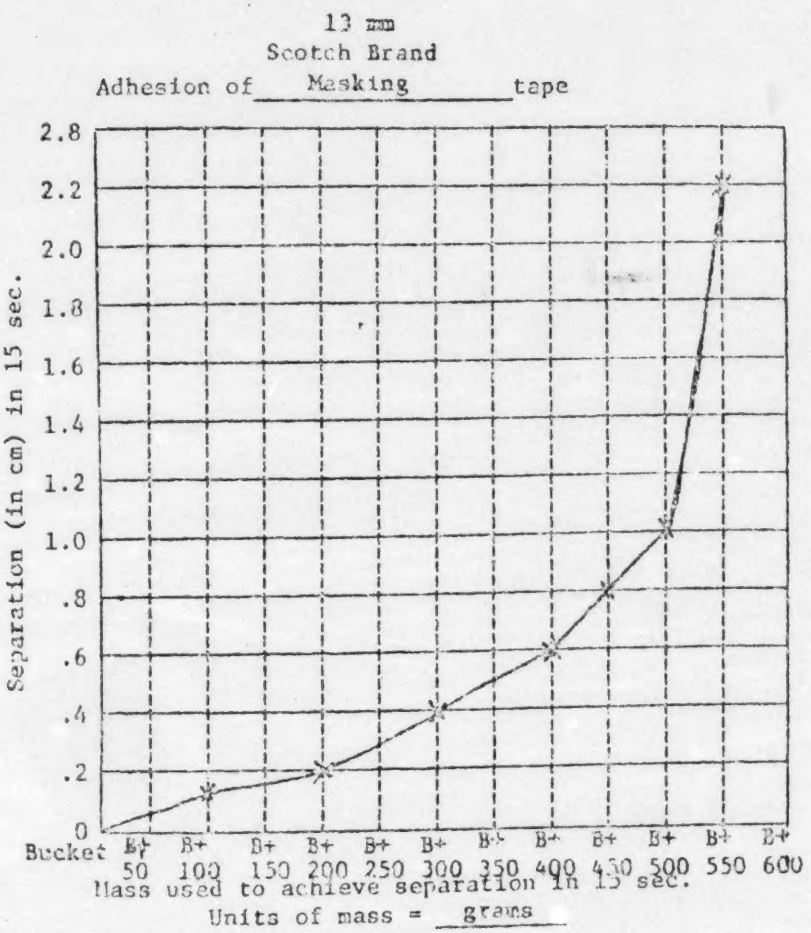
ADHESION OF TAPE

Tape Description
Scotch Brand Masking

Tape - 13 mm

Distance separated 15 sec	Total Mass
1 mm	Bucket +100gm
2 mm	B+ 200 gm
4 mm	B+ 300 gm
6 mm	B+ 400 gm
8 mm	B+ 450 gm
1.0 cm	B+ 500 gm
2.0 cm	B+ 550 gm

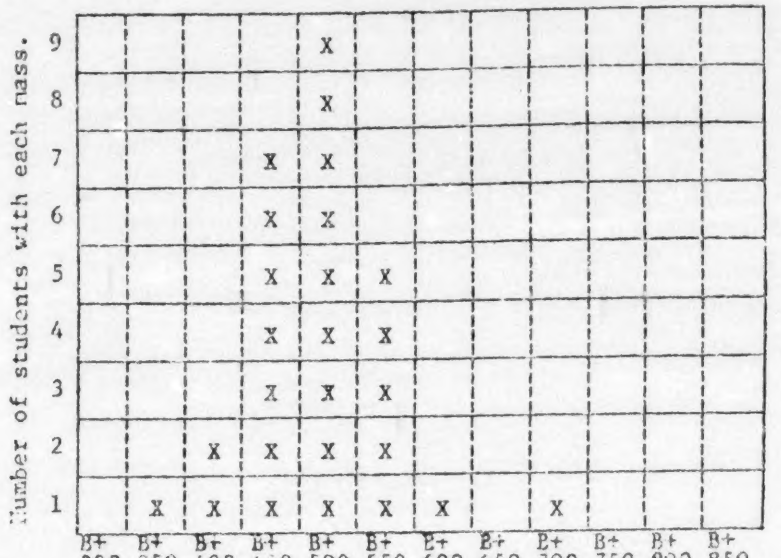
Mass required to separate 1 cm in 15 sec =



Class Results

Mass for 1 cm separation in 15 sec

B+ 300	B+ 500	B+ 450
B+ 400	B+ 550	B+ 500
B+ 600	B+ 500	B+ 500
B+ 450	B+ 450	B+ 450
B+ 400	B+ 500	B+ 550
B+ 450	B+ 500	B+ 450
B+ 550	B+ 550	B+ 700
B+ 500	B+ 500	B+ 450
B+ 500	B+ 550	


Number of students with each mass.
9
8
7
6
5
4
3
2
1
B+ 300 B+ 350 B+ 400 B+ 450 B+ 500 B+ 550 B+ 600 B+ 650 B+ 700 B+ 750 B+ 800 B+ 850
Mass needed for 1 cm separation/15 second units =

500

The Topeka Public and Parochial Schools
Unified School District No. 501
Environmental Education Demonstration Project
Phone: 232-9374

Tire Production and Pollution Control

Post-Module Test 263

Directions for Marking Your Answer Sheet:

Use only pencils to mark the answer sheet on this test.

Fill in the letter spaces in the column on the right side of the answer sheet for:

The first letter of your first name;
The first letter of your middle name;
All of the letters of your last name.

Write your name and school in the correct places on the top part of the answer sheet. Mark only one answer on each question and completely erase any changed answers.

1. What is the name for the sheet of rubber with cords in it that is in the tire?

   A. Tread
   B. Bead
   C. Sidewall
   D. Ply

2. Where is the tread pattern placed on the tire?

   A. Tread manufacturing machine
   B. Tire building station
   C. Tire curing press
   D. Final inspection station

3. What is not done to tires after they have been cured?

   A. They are run through the Banbury.
   B. They have small pieces of rubber cut off their edges.
   C. They are inspected to see if they are round.
   D. They have rubber ground off to make the white sidewall.

4. What will cause a permanent change in many properties of tire rubber?

   A. Stretching it until it breaks
   B. Heating it for several minutes
   C. Hitting it with sharp hammer blows
   D. Running it through a mill to make it very thin

5. A large piece of steel is pushed against the white sidewall of the tire in a test which measures:

   A. Tread thickness and elasticity
   B. Ply strength and elasticity
   C. Tread adhesion and endurance
   D. Bead strength and adhesion